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Organization of Hospital Nursing and Readmissions in Surgical Medicare Patients

Abstract
ABSTRACT

ORGANIZATION OF HOSPITAL NURSING AND READMISSIONS IN SURGICAL MEDICARE PATIENTS

Chenjuan Ma

Matthew D. McHugh

Linda H. Aiken

Hospital readmissions are prevalent and costly, particularly among older adults. They have been targeted as a field for improving quality of care and reducing healthcare cost. Nursing is a critical factor in determining the quality of patient care. Despite increasing evidence linking nursing to various patient outcomes; there is an absence of research examining the nursing-readmission relationship. The purpose of this study is to identify the association between organization of hospital nursing and readmissions in surgical Medicare patients. Three organizational features of hospital nursing were studied, nurse work environment, nurse staffing, and nurse education. A secondary analysis was completed using a multi-state nurse survey, Medicare patient discharge data, and American Hospital Association annual survey, collected in 2006-2007. A sample of 220,914 Medicare patients and 23,090 nurses from 528 hospitals in four states (CA, FL, NJ, and PA) were analyzed. Survey responses from the study nurses were used to construct the hospital level measures of nurse work environment, patient-to-nurse ratio, and nurse education preparation. The outcome of interest is 30-day readmissions. Cross-tabulations examined readmissions by patient, hospital, and nursing characteristics. Multivariate logistic regressions estimated the effects of work environment, nurse staffing, and nurse education on 30-day readmissions when adjusting for patient and hospital characteristics as well as considering clustering of patients within each hospital. The overall rate of 30-day readmission was 10% in surgical patients. In bivariate analysis, being black, sicker, and previously hospitalized increased the risk for 30-day readmissions; patients discharged from larger, teaching, and urban hospitals had higher 30-day readmission rates. In multivariate analysis, one standard deviation worse of the work environment score or adding one additional patient per nurse each was significantly associated with an increase of 3% in patients' likelihood of 30-day readmission. The significant association between work environment and readmission persisted when adjusting for nurse staffing. This study suggests that readmissions are not uncommon among surgical older patients and worth more attention. This study provides the first evidence that better nurse work environment and lower patient-to-nurse ratio are significantly associated with lower risk of surgical readmissions. Improving hospital work environment and nurse staffing may reduce readmissions in surgical older patients.

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ORGANIZATION OF HOSPITAL NURSING AND READMISSIONS IN SURGICAL MEDICARE PATIENTS

Chenjuan Ma

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In

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in

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ORGANIZATION OF HOSPITAL NURSING AND READMISSIONS IN SURGICAL MEDICARE PATIENTS

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Chenjuan Ma

DEDICATION

To my parents, Housong Ma and Hefen Chen; to my brother, Chenli Ma, for their love, encouragement, and constant support.

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ABSTRACT

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Hospital readmissions are prevalent and costly, particularly among older adults. They have been targeted as a field for improving the quality of care and reducing healthcare cost. Nursing is a critical factor in determining the quality of patient care. Despite increasing evidence linking nursing to various patient outcomes; there is an absence of research examining the nursing-readmission relationship. The purpose of this study is to identify the association between organization of hospital nursing and readmissions in surgical Medicare patients. Three organizational features of hospital nursing were studied, nurse work environment, nurse staffing, and nurse education. A secondary analysis was completed using a multi-state nurse survey, Medicare patient discharge data, and American Hospital Association annual survey, collected in 2006-2007. A sample of 220,914 Medicare patients and 23,090 nurses from 528 hospitals in four states (CA, FL, NJ, and PA) were analyzed. Survey responses from the study nurses were used to construct the hospital level measures of nurse work environment, patient-to-nurse ratio, and nurse education preparation. The outcome of interest was 30-day readmissions. Cross-tabulations examined readmissions by patient, hospital, and nursing characteristics. Multivariate logistic regressions estimated the effects of work environment, nurse staffing, and nurse education on 30-day readmissions when adjusting for patient and hospital characteristics as well as considering clustering of patients within each hospital. The overall rate of 30-day readmission was 10% in surgical patients. In bivariate analysis, being black, sicker, and previously hospitalized increased the risk for 30-day readmissions; patients discharged from larger, teaching, and urban hospitals had higher 30-day readmission rates. In multivariate analysis, one standard deviation worse of the work environment score or adding one additional patient per nurse each was significantly associated with an increase of 3% in patients' likelihood of 30-day readmission. The significant association between work environment and readmission persisted when adjusting for nurse staffing. This study suggests that readmissions are not uncommon among surgical older patients and require more attention. This study provides the first evidence that better nurse work environment and lower patient-to-nurse ratio are significantly associated with lower risk of surgical readmissions. Improving hospital work environment and nurse staffing may reduce readmissions in surgical older patients.

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CHAPTER 1: INTRODUCTION

The Problem

Prevalent and costly hospital readmissions have become a subject of increasing scrutiny within the U.S. health care system. Indeed, policymakers have singled them out as an occasion in which both improving quality of care and reducing health cost could be achieved. For example, reducing hospital readmissions is underscored under the U.S. Patient Protection and Affordable Care Act, which was signed by President Obama in March 2010. On the other hand, despite the increasing concern and awareness of the association between hospital readmissions and quality of health care, as evidenced by a prolific body of literature, surprisingly little empirical evidence exists examining the role of nursing – one of the most important components of the health service system – in hospital readmissions.

Patients in the U.S. are at uncommonly high risk for hospital readmissions, particularly older patients. One in five of the Medicare fee-for-service beneficiaries are readmitted within 30 days of discharge (Jencks, Williams, & Coleman, 2009). Unplanned readmissions of Medicare beneficiaries are estimated to cost Medicare $15-$17 billion per year (Jencks, et al., 2009; MEDPAC, 2007), which has become a heavy burden on the U.S. healthcare system. In the past two decades, despite the decrease in mortality rates, hospital readmission rates have been quite steady (Goodman, Fisher, & Chang, 2011) or even increased for some medical conditions (Jencks, et al., 2009).

Although some readmissions result from inevitable progression of disease or worsening of chronic conditions and are unavoidable; research has shown that a great number of readmissions are consequences of poor quality of care and can potentially be prevented (Ashton, Del Junco, Souchek, Wray, & Mansyur, 1997; Benbassat & Taragin, 2000; Oddone et al., 1996). The association between quality of hospital care and readmissions is further evidenced by the observed variations in risk-adjusted readmission rates across hospitals (Joynt, Orav, & Jha, 2011).

Consequently, hospitals are now expected to take major responsibility in the battle of reducing readmissions. Starting in 2012, hospitals with higher-than-expected rates of readmissions will bear Medicare payment penalties under the Patient Protection and Affordable Care Act (Kocher & Adashi, 2011). This “payment penalty” strategy first starts among patients with heart failure, acute myocardial infarction, and pneumonia; and it will soon expand to cover other medical conditions as well as some surgical conditions by 2015 (Axon & Williams, 2011). In addition, hospital 30-day readmission rates have been endorsed as a metric of the quality of hospital care and are reported at the website HospitalCompare, which is accessible for public review.

Some programs have been developed to reduce hospital readmissions; however, systematic reviews have shown that the majority of these programs focus only on discharge planning or post-discharge care, and not all of the available interventions to reduce readmissions are effective (Horwitz et al., 2011; Mistiaen, Francke, & Poot, 2007). As a result, there exists continued interest of the health care professionals, hospital administrators, and policymakers in further searching for new ways to reduce hospital readmissions.

Under the appeal for new strategies to reduce hospital readmissions, there has been a rapid increase in studies examining the relationship between quality of hospital care and readmissions. However, nursing, as a "critical factor in determining the quality of care in hospitals and the nature of patient outcomes" (Wunderlich, Sloan, & Davis, 1996) and an important attribute of hospital care delivery system that can be fully managed and modified by hospital executives, has been frequently excluded from these studies.

The nursing workforce constitutes the largest group of health care providers. Over 1.5 million registered nurses are providing care to patients in hospitals and they account for as much as 44% of direct costs of inpatient care (Bureau of Labor Statistics, 2009; Kane & Siegrist, 2002). Hospital nurses provide direct 24/7 bed-side care to patients. In addition to direct patient care, nurses function as a surveillance system for early detection of patient complications, adverse events, and other care needs (Clarke & Aiken, 2003; Kutney-Lee, Lake, & Aiken, 2009), which is vital to prevent readmissions.

Nurses provide direct patient care and perform surveillance functions in hospitals with different organizational features of hospital nursing. Three main features of hospital nursing organization are the nurse work environment, nurse staffing, and nurse education. The nurse work environment can be defined as “the organizational characteristics of a work setting that facilitate or constrain professional nursing practice.” (Lake, 2002) Nurse staffing measures nurses’ workloads for patient care. Nurse education indicates how well nurses are prepared to care for patients in terms of professional knowledge in making clinical judgment. Previous studies have identified an association between hospital nursing organization and certain patient outcomes. Specifically, more favorable nurse work environment, better nurse staffing, and more nurses prepared at the baccalaureate level or higher are associated with better patient outcomes, such as lower mortality rates, less failure-to-rescue and complications (Aiken, Clarke, Sloane, Lake, & Cheney, 2008; Aiken, Smith, & Lake, 1994; Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Friese, Lake, Aiken, Silber, & Sochalski, 2008; Kane, Shamliyan, Mueller, Duval, & Wilt, 2007; Kutney-Lee & Aiken, 2008; Needleman et al., 2011; Van den Heede et al., 2009).

These findings suggest that improving hospital nursing organizational attributes may improve patient outcomes. While increasing evidence on the nursing-outcomes relationship exists, there is a scarcity of research linking features of hospital nursing to hospital readmissions, particularly among older patients.

Older adults are an important population in studies examining the relationship between hospital care and readmissions for several reasons. Older adults are more likely to be hospitalized. Approximately one in three of the older adults (aged 65 and above) are hospitalized into short stay hospitals annually (AOA, 2010a). This hospitalization rate is about three times the comparable rate for persons of all ages (Timms, Parker, Fallat, & Johnson, 2002). Hospitalizations also put older adults at additional risk for iatrogenic infections, complications and other adverse events, which may cause extended hospital stays and hospital readmissions (Steiner, Barrett, & Hunter, 2010). In addition to a higher hospitalization rate, older adults are more likely to be readmitted within a short period following a hospital stay when compared to younger adults (Steiner, et al., 2010).

Furthermore, the rapid increase of the older population results in dramatically higher demand for healthcare that leads to tremendous health costs. This challenges nursing and allied health professions that are concerned with improving quality of care while controlling health costs (Timms, et al., 2002). Older adults aged 65 and above now comprise 13% (44 million) of the U.S. population, and will reach 20% by 2030. As age increase, older adults are more susceptible to chronic conditions and functional loss (AOA, 2010b). The majority of older adults have at least one chronic condition and many have multiple conditions. Approximately 42% of the older adults report one functional limitation and 25% of them have difficulty in at least one daily living activity (AOA, 2010a). Consequently, the aging of the US population will result in an increase in utilization of surgical services; and even worse, this increase will far outpace the rate of the overall older population growth (Etzioni, Liu, Maggard, & Ko, 2003).

In this study, I further narrow the study population to older adults who are hospitalized for general, orthopedic, or vascular surgical procedures in acute care hospitals. I chose this surgical group for several reasons. First, these surgeries are commonly performed at almost every hospital (Silber, Rosenbaum, & Ross, 1995) and there are large numbers of patients undergoing these procedures. Validated risk adjusted models in patient outcomes research among this group of patients are available (Aiken et al., 2011; Press et al., 2010). In addition, this is a population with concerns of hospital readmissions but has not been well studied to date (Goodman, et al., 2011). Most of the studies on readmissions thus far have been conducted among patients with chronic conditions; to the best of my knowledge, only two studies have studied the overall surgical readmission rates among older adults involving a broad scope of diseases using a national sample (Anderson & Steinberg, 1984; Jencks, et al., 2009).

In summary, the prevalence of hospital readmissions signals concerns regarding the quality of inpatient care. Nursing is a critical component of the hospital care delivery system and it affects quality of care and patient safety. While there is evidence linking the organization of hospital nursing to certain patient outcomes, there is an absence of studies examining the role of nursing organization in hospital readmissions, particularly among older adults undergoing surgeries. A study to address this gap in the literature will advance the science in this area.

Study Purpose, Specific Aim, and Hypotheses

The purpose of this study is to examine the association between hospital nursing organization and readmissions among Medicare beneficiaries undergoing general, orthopedic, and vascular surgeries. The outcome of interest is hospital readmission, with a primary focus on 30-day readmission. In this study, 30-day readmission is defined as all-cause readmissions to any acute care hospitals within 30 days of discharge following a general, orthopedic, or vascular surgery. The 30-day timeframe was used to define readmissions because readmissions are more likely attributable to the quality of care during the index admission within a 30-day time frame (Horwitz, et al., 2011). In addition, the 30-day timeframe has been frequently used as a standardized measure of hospital readmissions and quality of care in other seminal studies as well as for public reports.

Specific Aims

Aim 1: To examine the incidence, variation, and reasons of readmissions within 30 days from discharge in Medicare patients undergoing general, orthopedic, and vascular surgeries.

Aim 2: To identify the extent to which hospital nursing organization, specifically nurse work environment, nurse staffing, and nurse education, is associated with 30-day readmissions in Medicare patients undergoing general, orthopedic, and vascular surgeries.

H1: Patients discharged from hospitals with better nurse work environment, lower patient-to-nurse ratio, and higher proportion of nurses with baccalaureate degrees and above are less likely to have a 30-day readmission.

Study Significance

Poor quality of inpatient care often results in undesirable patient outcomes. Despite the increase in the number of studies investigating the causal mechanism of hospital readmissions, nursing has been frequently neglected. Meanwhile, associations between organizational features of hospital nursing and other patient outcomes, such as mortality, failure-to-rescue, and patient satisfaction, have been consistently documented (Aiken, et al., 2008; Aiken, et al., 1994; Aiken, et al., 2002; Friese, et al., 2008; Kane, et al., 2007; Kutney-Lee & Aiken, 2008; Needleman, et al., 2011; Van den Heede, et al., 2009). These findings suggest that there may also be a direct effect of hospital nursing organization on hospital readmissions. This study will take an initial step to link three organizational features of hospital nursing (namely the nurse work environment, nurse staffing, and nurse education) to hospital readmissions in a vulnerable population - older adults undergoing surgeries.

The findings on the incidence, variation, and reasons of hospital readmissions following surgeries provide new knowledge to our understanding of the phenomenon of readmissions and its potential causes, which in turn will be informative to identify effective interventions to reduce readmissions and health cost. To the best of my knowledge, as aforementioned, there are only two studies that have examined readmissions among older patients involving a wide range of surgeries. Because the majority of older adults have at least one comorbid condition, findings from this study may provide baseline information for further studies of readmissions among patients with chronic conditions (e.g. heart failure and diabetes) who are undergoing surgery.

Use of the Multi-State Nursing Care and Patient Safety Survey (PI: Linda Aiken) in this study provides a unique opportunity to investigate the relationship between hospital nursing organization and readmissions. One of the barriers in studying the role of nursing in patient outcomes is the availability of reliable nursing measures. The multi-state nurse survey collected information directly from a large random sample of nurses (over 1,000,000 nurses) from California, Florida, New Jersey, and Pennsylvania. In addition to information on nurse staffing and nurse education, this survey provides unique and reliable measures of the nurse work environment (Lake, 2002), which are not available in other administrative and clinical data. Thus this study will provide invaluable information to better understand the context of patient care settings and its relationship to patient outcomes.

The findings of the role of hospital nursing organization in readmissions are informative to various healthcare stakeholders. The results are instructive to hospital administrators in optimizing nursing sources to improve quality of care and patient outcomes, particularly reducing readmissions, which can further help hospitals avoid or reduce potential risks for financial penalties resulting from high readmission rates. By illustrating what hospital characteristics are linked with superior outcomes, findings from this study will empower patients and their families to make more informed decision when choosing hospitals for surgeries. The findings of this study will also interest health outcome researchers. The exploration of the association between hospital nursing organization and readmissions among older adults undergoing surgeries will expand our knowledge of the nursing-outcomes relationship; and provide evidence to explain variations in geriatric outcomes.

CHPATER 2: BACKGROUND AND SIGNIFICANCE

Introduction

This chapter begins with a description of the theoretical framework that guides this study – the Quality Health Outcomes Model. It is followed by a synthesis of literature on hospital readmissions and their association with patient characteristics, hospital structural characteristics, and hospital nursing organization. This chapter is completed by a summary of gaps in the extant literature.

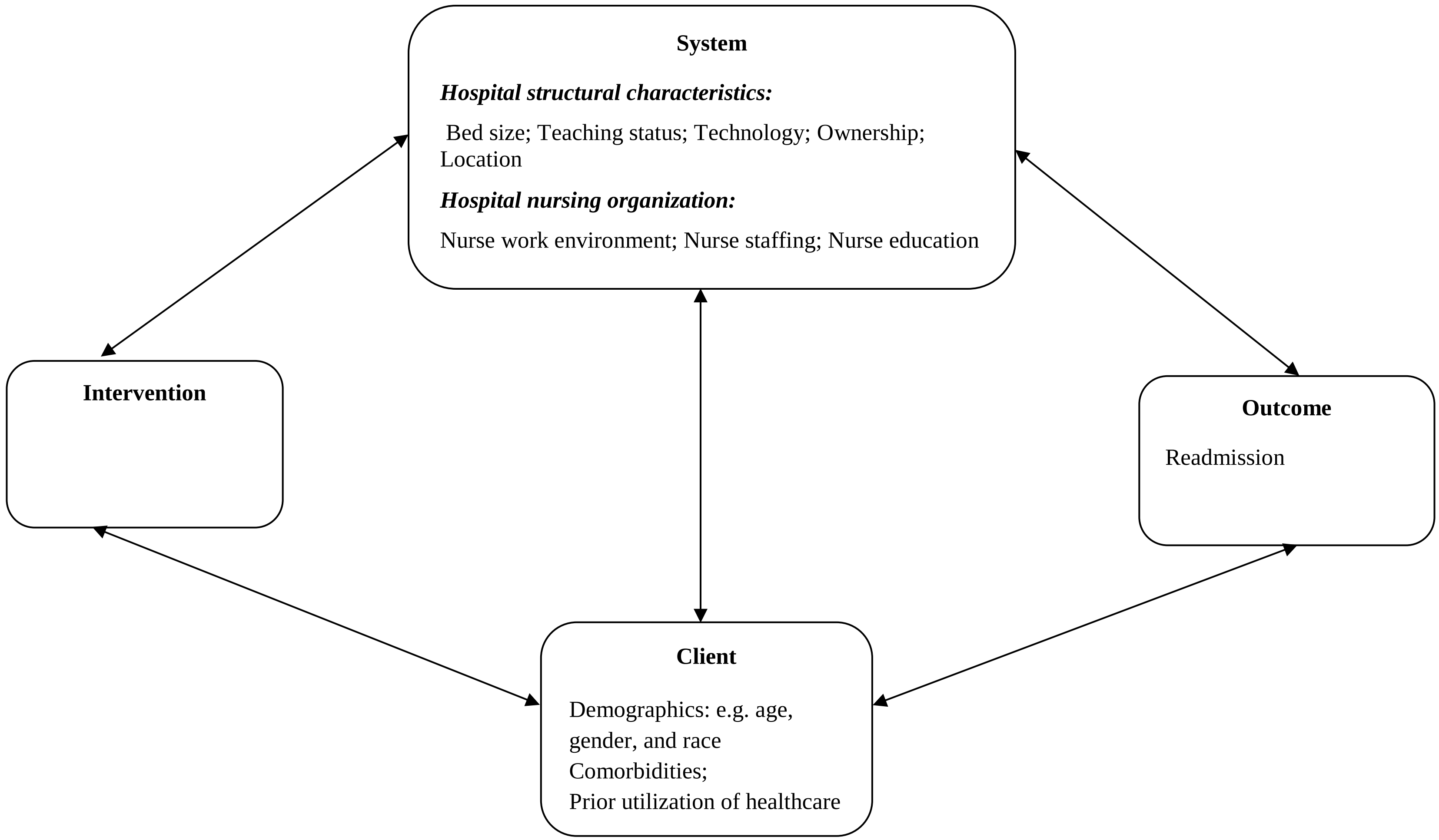
Theoretical Framework

The theoretical framework that guides this study is the Quality Health Outcomes Model by Mitchell and colleagues (Mitchell, Ferketich, & Jennings, 1998). This model is an elaboration and extension of Donabedian's (1966) structure-process-outcome model (Donabedian, 1966; Mitchell, et al., 1998). Both of the models were designed with the purpose of guiding quality of care evaluation and research. Donabedian conceptualized a linear relationship between the components of the model (structure affects process, which in turn influences outcomes). Incorporating new findings in health outcomes research, Mitchell and colleagues extended Donabedian's linear model into the dynamic Quality Health Outcomes Model, which captures the multiple feedback loops between the components of the model. The Quality Health Outcomes Model includes four components: system, intervention, client, and outcome. According to Mitchell and colleagues, the relationships between the four components are bidirectional; and the effect of intervention on outcome is not direct but mediated by system characteristics and client characteristics.

The system component in the Quality Health Outcomes Model is akin to Donabedian's concept of structure, and refers to the characteristics of an organized setting where health care is provided. The intervention refers to any direct and indirect health care activities provided. The client component refers to the characteristics of the client that influence the outcome. Examples of client characteristics are demographics and comorbidities. Finally, the outcome indicates "results of care structures and processes that integrate functional, social, psychological, physical, and physiologic aspects of people's experience in health and illness" (Mitchell, et al., 1998).

For the purpose of this study, three of the four components are included: system, client, and outcome. The system herein refers to structural and nursing characteristics of the hospitals. Hospital structural characteristics include bed size, teaching status, ownership, technology, and location. Hospital nursing characteristics include nurse work environment, nurse staffing, and nurse education. The client refers to older surgical inpatients (aged 65-89). Their demographics and health related information will be included as risk factors. Finally, the outcome in this study is readmission.

Figure 2.1 Theoretical Framework Adapted from the Quality Health Outcomes Model (QHOM)



Mitchell, Ferketich, & Jennings, 1998

Review of the Literature

Readmissions

Research on readmission can be traced back to the 1950s among psychiatric patients (e.g. patients with schizophrenia) (Israel & Johnson, 1956; Jenkins, Bemiss, & Lorr, 1953; Michtom, Goldberg, Offenkrantz, & Whittier, 1957; Wanklin, Fleming, Buck, & Hobbs, 1956). In the past two decades, the older population (65 years or older) has become the focus of readmission research. Two reasons may explain this change in the targeted study population. First, older adults are at a higher risk for hospital readmissions when compared to younger adults. Second, there is a rapid increase in the older population in the U.S. Estimates suggest that adults aged 65 and above will comprise 20% (70 million) of the U.S. population by the year 2030, increasing from the current 13% (44 million) (AOA, 2010b). That is approximately a 60% increase.

To date, tremendous effort has been made by researchers to unveil the mechanism of readmission. Overall these studies can be categorized into the following three groups in terms of their research purposes: 1) studies focusing on describing the incidence and ensuing cost of readmissions; 2) studies focusing on investigating factors associated with or predicting readmissions; and 3) studies focusing on identifying effective interventions to reduce readmissions.

Researchers studying the incidence of readmissions and the associated healthcare cost have repeatedly documented that readmissions are prevalent and costly, particularly among older adults. Anderson and Steinberg conducted one seminal study on this topic in 1984. Their study was considered the first study that examined all-cause readmissions in a national sample of Medicare beneficiaries with a wide range of diagnoses. Its findings were published in the *New England Journal of Medicine.* The study sample included 270,260 Medicare beneficiaries and their 420,903 discharges during the time period of 1974 - 1977. Researchers found that 23% of the Medicare discharges were followed by a readmission within 60 days of discharge; and 50% of the Medicare discharges were followed by a readmission within 365 days of discharge. They also estimated that readmissions within 60 days of discharge cost almost one fourth of the Medicare inpatient expenditures.

More recently, another study that examined all-cause readmissions among Medicare patients was published in 2009 by Jencks and colleagues (Jencks, et al., 2009). It has become one of the most frequently cited articles in readmission research. Jencks et al reported several important findings. They reported that approximately 20% of the Medicare beneficiaries discharged from acute care hospitals were rehospitalized within 30 days of discharge, and the cumulative readmission rates at 60 days and 365 days were 28% and 56%, respectively. It also estimated the health cost resulting from readmissions and indicated that Medicare paid $17 billion for unplanned hospital readmissions in 2007. These results are consistent with the findings by Anderson and Steinberg. Readmission rates have not decreased in the past two decades; they have even increased among patients with certain conditions (Goodman, et al., 2011). It is reasonable to hypothesize that health cost, particularly Medicare expenditures, could be dramatically decreased even with a small reduction in readmission rates.

Jencks et al. further investigated readmissions by patient medical condition and found that surgical patients were at high risk for readmissions. They reported that patients hospitalized for surgical procedures have a 30-day readmission rate of 16%; and among these surgical patients, vascular patients had the highest readmission rate (24%), followed by hip/femur patients (18%) and patients undergoing major bowel surgery (17%). Similarly, statistics from the annual *National Hospital Discharge Survey* also showed that millions of older adults are hospitalized for surgeries of the digestive system, the circulatory system, and knee or hip replacements (Buie, Owings, Defrances, & Golosinskiy, 2010; Hall, DeFrances, Williams, Golosinskiy, & Schwartzman, 2010). Furthermore, the demand for such surgeries is increasing rapidly. For example, in a study of the aging population and its impact on surgical services, Etzioni and colleagues projected that the aging U.S. population would result in significant increases (14 - 47%) in the demand for surgical services (Etzioni, et al., 2003). Using the year 2008 as reference, another study estimated that the volume of vascular procedures would increase 34% to 1,590,000 procedures by 2020 or 72% to 2,031,000 procedures by 2030. Researchers studying readmissions thus far have mainly focused on patients with chronic conditions; thus, one group that appears to deserve close evaluation is patients who have undergone surgeries.

Researchers studying factors predicting readmissions have suggested a large array of potential risk factors. One systematic review by Kansagara and colleagues analyzed 26 readmission risk prediction models that have been tested in a variety of patients and settings (Kansagaran et al., 2011). They found that patient characteristics (e.g.

demographics and comorbidities), some clinical information (e.g. diagnosis and severity of illness), and several hospital characteristics (e.g. bed size, teaching status, and location) were the most frequently used variables in predicting readmissions. Other researchers have reported that hospital system factors, such as hospital discharge planning and patient safety climate, are related to readmissions as well (Ashton, et al., 1997; Luke O. Hansen, Williams, & Singer, 2011). Among these identified risk factors, it should be noted that nursing has not been included. Readmission is a complex and multifaceted process; and each discipline may play a role in it. The key to reducing readmission is to identify those risk factors that occur frequently and are amenable to intervention.

Effort has been made to develop programs to reduce readmissions. Some of these programs have achieved success in reducing readmission, such as the advanced practice nurse (APN) directed transitional care program by Naylor and colleagues and the reengineered discharge program by Jack and colleagues (Coleman, Parry, Chalmers, & Min, 2006; Jack et al., 2009; Naylor et al., 2004; Wick et al., 2011). A closer review of these programs reveals that nurses are the key players in implementing these interventions, which implies a direct effect of nursing care on hospital readmissions. However, there is a scarcity of evidence linking inpatient nursing care to readmissions.

Patient characteristics and readmissions

Patient demographic characteristics and comorbid conditions are important factors to be considered in health outcomes research because they affect patient outcomes

(Iezzoni, 2003). These patient characteristics are considered non-modifiable because they are not easily changed; they are often used for risk adjustment.

Patient basic demographic characteristics usually include age, gender, and race. As age increases, patients are more vulnerable to longer hospital stays and being readmitted within a short period after discharge (Kagan et al., 2002; Kossovsky et al., 2000; Martin et al., 2011). For example, Toraman and colleagues report that patients 65 years or older are more likely to be readmitted to an intensive care unit after coronary artery bypass grafting (CABG) (OR=2.9, 95% C.I, 1.5-5.4, p=0.001) (Toraman, Senay, Gullu, Karabulut, & Alhan, 2010). The association between gender and hospital readmissions is more complex. Some research has shown that gender has a significant effect on patients' risk for hospital readmissions: male patients have a higher readmission rate in general (Greenblatt et al., 2010; Jencks, et al., 2009; Lindenauer et al., 2011). However, among CABG patients, females are more likely to stay longer and be readmitted (Butterworth et al., 2000; Guru, Fremes, Austin, Blackstone, & Tu, 2006; Vaccarino et al., 2003). Other studies have suggested that there is no significant relationship between gender and readmission (Hasan et al., 2009; Wick, et al., 2011). The inconsistency in the effect of gender on hospital readmissions may result from the differences in the ways in which male and female patients respond to the diseases and treatment/care. Racial disparities exist in readmission rates. White patients are more likely to be discharged earlier and are less likely to be readmitted (Joynt, et al., 2011; Mahmoud, Turpin, Yang, & Saunders, 2009).

Comorbidities are preexisting medical conditions that are not directly related to the principal diagnosis of hospitalization but may lead to poorer outcomes or higher health costs (Elixhauser, Steiner, Harris, & Coffey, 1998). Literature has repeatedly documented a strong association between readmissions and patients' comorbidities. In a study of risk factors associated with unplanned hospital readmissions among Medicare beneficiaries, researchers found that as the number of comorbidities increased, the risk of being readmitted also increased (Marcantonio et al., 1999). Specifically, they reported that the patients with five or more comorbidities had a readmission odds of 2.6 compared to those with less than five comorbidities.

Prior utilization of healthcare has been identified as another factor influencing readmission rates. One study found that a patient's likelihood of being readmitted within 30 days of discharge increased significantly as the number of hospitalizations in the past year increased (Howell, Coory, Martin, & Duckett, 2009). When compared to patients without hospitalization in the past year, the odds for 30-day readmission was 1.45 for patients with one prior hospitalization, and 1.63 for patients with two or more prior hospitalizations.

Hospital structural characteristics and readmissions

Similar to patient characteristics, hospital structural characteristics are often included as control variables for risk adjustment in health outcomes research. This is because hospital characteristics are often associated with readmissions (Krumholz et al., 2009), but they are difficult to change and thus are non-modifiable attributes of hospitals. Frequently studied hospital structural characteristics are teaching status, bed size, ownership, and technology status. Readmission rates vary by hospital teaching status. The majority of research suggests that teaching hospitals have the same or lower readmission rates compared to non-teaching hospitals (Ghaferi, Osborne, Birkmeyer, & Dimick, 2010; Khuri et al., 2001). Larger hospitals, usually measured as the bed capacity of the hospital, are associated with lower 30-day readmission rates (Joynt & Jha, 2011). Hospitals with sophisticated technological capacities, such as performing open-heart surgeries and organ transplants, have been associated with lower readmission rates (Ghaferi, et al., 2010; Joynt, et al., 2011; Shortell et al., 1994).

In this study, these aforementioned hospital structural characteristics together with patient characteristics (demographics, comorbidities, and prior utilization of healthcare) are included as the control variables for risk adjustment in examining the effect of hospital nursing organization on readmissions.

Hospital nursing organization and patient outcomes

The organization of hospital nursing care is a core component of the hospital health care delivery system. Three important features of the hospital nursing organization are the nurse work environment, nurse staffing, and nurse education. Previous studies have reported that these features of hospital nursing organization are associated with a variety of patient outcomes (Aiken, S. Clarke, R. Cheung, D. Sloane, & J. Silber, 2003; Aiken, et al., 2008; Aiken, et al., 2011; Lake, Shang, Klaus, & Dunton, 2010).

Research on the nursing work environment was driven by nurse shortages and high requirements on quality of care in the late 1970s and 1980s. The nurse work environment is the practice setting and context in which nurses deliver care and function as a surveillance system. To allow nurses to practice up to their full capacities, a supportive professional work environment with features including but not limited to autonomy, managerial support, adequate nursing resource, good physician-nurse relationships, and nurses' participation in hospital affairs is desired (Lake, 2002). An association between professional nurse work environment and lower mortality rates has been found in several studies (Aiken, et al., 1994; Aiken, Sloane, Lake, Sochalski, & Weber, 1999). This relationship continues to exist when adjusting for nurse staffing and nurse education, as well as other hospital and patient characteristics (Aiken, et al., 2008). Supportive nurse work environments are also associated with lower odds of failure-to-rescue among surgical patients as well as in oncology patients (Aiken, et al., 2008; Friese, et al., 2008).

Nurse staffing is a reflection of the intensity of patient care required from nurses. Different methods are used to measure the levels of nurse staffing, such as patient-to-nurse ratio, RN full-time equivalents per 1000 inpatient days, and nurse hours per patient day, to name only a few. Despite the variations in calculating the nurse staffing level, significant associations between nurse staffing and patient outcomes has been consistently documented (Blegen, Goode, Spetz, Vaughn, & Park, 2011; Cho, Ketefian, Barkauskas, & Smith, 2003; Harless & Mark, 2010; Kane, et al., 2007; Needleman, et al., 2011; Person et al., 2004; Van den Heede, et al., 2009). According to a study by Aiken et al, each additional patient per nurse was associated with a 7% increase in the odds of 30-day mortality and failure-to-rescue (Aiken, et al., 2002).

Nurse education reflects the amount of nursing training that nurses received and is related to patient outcomes. A seminal study by Aiken and colleagues, which was published in the *Journal of the American Medical Association*, indicates that an increase of 10% in the proportion of nurses holding bachelor degrees or above is associated with a 5% decrease in both the odds of 30-day mortality and failure-to-rescue after controlling for patient and hospital characteristics (Aiken, et al., 2003).

Despite increasing evidence documenting the importance of the hospital nursing organization in improving patient outcomes; research examining the role of hospital nursing organization in readmission is scant. To date, to the best of my knowledge, no research has examined the hospital nurse work environment and nurse education in relation to readmissions in surgical patients; and only two studies were found that have investigated the levels of hospital nurse staffing in relation to readmissions (Diya, Van den Heede, Sermeus, & Lesaffre, 2011; Joynt & Jha, 2011). Both of these studies reported a significant association between nurse staffing and readmission rates. Joynt and Jha found that patients discharged from hospitals in the lowest quartile of nurse staffing (measured as the full-time equivalent per 1000 patient-days) had significantly higher readmission rates than those discharged from hospitals in the highest quartile (29% vs. 25%, $p<0.001$). The other study is from Belgium and studied patients readmitted into intensive care units and/or the operating room. It found that readmission rates were negatively associated with nurse staffing, measured as hours per patient day.

Summary

The prevalence of costly and preventable readmissions among older adults and the rapid increase in the older population result in increasing interests in identifying effective interventions to reduce hospital readmissions. Surgical patients are a large population and are at high risk for hospital readmissions. To date, the majority of research studying readmissions has been focused on patients with chronic conditions. Furthermore, despite a prolific body of studies on readmission, nursing is rarely considered. On the other hand, there is increasing evidence linking the hospital nursing organization to other patient outcomes (e.g. mortality, failure-to-rescue, and complications). It is reasonable to hypothesize that the hospital nursing organization is associated with readmissions. However, evidence linking the hospital nurse work environment, nurse staffing, and nurse education, which are the three main features of hospital nursing organization, to hospital readmissions is absent. This proposed study aims to narrow these gaps in health service research by examining the patterns of surgical readmissions and investigating the association between hospital nursing organization and readmissions among Medicare beneficiaries undergoing general, orthopedic, and vascular surgeries.

CHAPTER 3: METHODS

Introduction

The purpose of this study is to describe the patterns of readmissions and investigate the association between the hospital nursing organization (hospital nurse work environment, nurse staffing, and nurse education) and readmissions in Medicare patients undergoing general, orthopedic, and vascular surgeries. This chapter describes the design and methods addressing the specific aims in this study. These include description of data sources, study sample, variables and instrument, and data analysis plan. It ends with a discussion of human subject issues.

Data Sources

This study was a cross-sectional secondary analysis of linked nurse survey data, hospital administrative data, and patient discharge data from four states (California, Florida, New Jersey, and Pennsylvania). Three data sources were used: 1) the 2006-2007 Multi-State Nursing Care and Patient Safety Survey (PI: Linda Aiken) by Center for Health Outcomes and Policy Research, the University of Pennsylvania (Aiken, et al., 2010; Aiken, et al., 2011); 2) the 2006-2007 patient discharge data from the Centers for Medicare and Medicaid Services (CMS); and 3) the 2007 American Hospital Association (AHA) Annual Survey

The Multi-State Nursing Care and Patient Safety Survey

The parent study was conducted in 2006-2007 in the four study states (CA, FL, NJ, and PA). A two-stage sampling design derived from the Dillman survey approach (Dillman, 1978) was employed to collect data. State nurse licensure lists were used as sampling frames. A large sample of registered nurses (RNs) (106,532 RNs in California, 49,385 RNs in Florida, 52,545 RNs in New Jersey, and 64,321RNs in Pennsylvania) were randomly selected from the nurse licensure lists from the four states. Surveys were mailed to the sampled nurses at their home addresses. As a strategy to encourage the response rate, a second survey and a reminder postcard were sent out following the first mailed survey. By the end of the survey, in total over 100,000 surveys were completed, which generated a response rate of 39% (Aiken, et al., 2011). Data collected from the survey provides information on nursing care and patient safety. It measures, but is not limited to, nurse work environment, nurse reported patient care workload, nurse education background, nurse outcomes (burnout and job satisfaction), nurse assessed patient safety, and nurse demographic information. To address potential response bias, another random sample of 1,300 non-responders in California and Pennsylvania was surveyed. With additional response-encouraging strategies such as phone calls, priority mail, and cash incentives, the second survey generated a response rate of 91%. A comparison between the two samples was conducted (Smith, 2008). The results from the analysis indicated that there was no evidence of differences in nurse reported nurse work environment, staffing, and other information on work conditions explored in this study; although there were some differences in demographics between the two groups. More detailed information about this nurse survey was published elsewhere (Aiken, et al., 2011).

The sampled nurses in the parent survey included nurses working in different health care settings. Nurses who indicated that they worked in hospitals were requested to indicate their principal employing hospitals from a list of all acute care hospitals within each state. For each nurse respondent, as well as each hospital in the survey, a unique ID was assigned. The hospital IDs later were used to link the nurse survey data to the patient and hospital data. For the purpose of this study, only nurse respondents reporting working in non-federal acute care hospitals were included.

Patient discharge data

All patient data was obtained from the CMS Chronic Condition Data Warehouse through the Research Data Assistance Center (ResDAC). The received data package includes two data files, the Medicare Provider and Analysis Review File (MedPAR) data file and Beneficiary Annual Summary File (BASF) Documentation data file. The MedPAR data file provided detailed information on inpatient hospital stays, including diagnosis (ICD-9 diagnosis), procedure (ICD-9 procedure code), Diagnosis Related Groups (DRGs), date of admission, admission type, length of stay, hospital provider identifier, date of discharge, discharge status (alive/dead) and destination. The BASF file provides data on Medicare beneficiaries' demographics (e.g. date of birth, gender, and race/ethnicity), benefit/coverage, and date of death. The two data files can be linked via de-identified unique Medicare beneficiary IDs.

AHA annual survey

The AHA annual survey provided comprehensive and authoritative data on hospitals in the U.S, including hospital organizational structure, facilities and services, utilization data, physician arrangements, staffing, and community orientation. It has been widely used in health services research. In this study, the 2007 AHA annual survey data was used to identify hospital structural characteristics that might have influence on health care delivery and patient outcomes. These hospital characteristics were included in the analytic models as control variables for risk adjustment. Specifically, the hospital structural characteristics that were included in this study were hospital ownership, bed size, teaching status, technology level, and location.

Study Sample

Nurses

Registered nurses who completed the Multi-State Nursing Care and Patient Safety Survey were included in this study if they: 1) were staff nurses providing direct patient care; and 2) worked in non-federal acute care hospitals. Responses to the survey from these nurses were used to construct measures of hospital nurse work environment, nurse staffing and nurse education. The final nurse sample in this study included 23,090 nurses with a mean number of 44 nurses per hospital.

Patients

The 2006-2007 Medicare beneficiary discharge data, including MedPAR data file and BASF data file, were used to identify eligible patients. The patient inclusion criteria were: 1) Medicare fee-for-service (FFS) enrollees aged 65-89. Patients aged 90 years or above were excluded. Because the proportion of such patients that are treated aggressively may change over time in administrative data (Volpp, et al, 2007); 2) hospitalized for general, orthopedic, or vascular surgery procedures in non-federal acute care hospitals in California, Florida, New Jersey, and Pennsylvania; and 3) survived to discharge. Patients were excluded if they were: 1) discharged against medical advice; 2) admitted and discharged on the same day; 3) transferred from or to another hospital during one stay; and 4) readmitted for rehabilitation (readmission DRG of “462”). In the final sample, 220,914 patients were included.

Hospitals

Hospitals were included in this study if they met the following criteria. First, the hospital had at least 8 eligible nurse respondents in the nurse survey data. I used this criterion to ensure that the aggregated measures of hospital nursing organizational characteristics from individual nurse respondents were representative and reliable. One-way analysis of variance was performed to identify the intra-class correlation coefficient (ICC) at the hospital level. The ICC (1, k) is an index of the mean inter-rater reliability of the aggregated data, and has been considered as the most appropriate reliability index for aggregated data. Researchers have suggested that an ICC (1, k) of above 0.60 indicates the aggregated measure is reliable (Forbes & Taunton, 1994; Hughes & Anderson, 1994). My analysis reported that the ICCs (1, k) of the subscales measuring the different dimensions of the nurse work environment ranged from 0.72 to 0.89. The ICC (1, k) was 0.84 for the composite measure of the nurse work environment. These results suggested that the aggregated measures for hospitals with at least 8 nurses were reliable. Second, the hospital’s structural characteristics could be identified in the AHA annual survey data. Third, the hospital has at least 50 surgical discharges annually. The total number of hospitals included was 528.

Variables and Instruments

Hospital Nursing Organization

Three variables indicating the hospital nursing organization were derived from the Multi-State Nursing Care and Patient Safety Survey. These variables included nurse work environment, nurse staffing, and nurse education.

Nurse work environment. The nurse work environment was measured using the Practice Environment Scale of the Nursing Work Index (PES-NWI), which is one of the nurse-sensitive instruments recommended by the National Quality Forum. The PES-NWI was developed from the Nursing Work Index (NWI) and Revised Nursing Work Index (NWI-R, Aiken & Patrician, 2000) and its validity and reliability have been tested (Lake, 2002). The PES-NWI has been used widely in the U.S and other countries (Warshawsky & Havens, 2011). It includes 31 items and consists of five subscales measuring different dimensions of the nurse work environment: nurse participation in hospital affairs (8 items); nursing foundation for quality of care (9 items); nurse manager ability, and support of nurses (4 items); staffing and resource adequacy (7 items); and collegial nurse-physician relations (3 items). Each item is scored on a four-point Likert-type scale from strongly agree to strongly disagree. Research has shown high reliability and validity of the PES-NWI scale. It has an overall Cronbach's alpha of 0.82; and the Cronbach's alphas for each subscales range from 0.71 to 0.84 (Lake, 2002).

Previous research using the PES-NWI has suggested that two of the five subscales (staffing and resource adequacy and nurse participation in hospital affairs) may be highly correlated with direct measures of nurse staffing and nurse education (Aiken, et al., 2008). In the preliminary analysis, I found that the correlation between staffing and resource adequacy and the direct measure of nurse staffing (patient-to-nurse ratio) was moderate at the hospital level (r=-0.50), and the correlation between nurse participation in hospital affairs and the direct measure of nurse education was low (r=0.19). I omitted the staffing and resource adequacy subscale from the calculation of the composite score of the PES-NWI. Thus, four subscales were used to measure the hospital nurse work environment. A hospital level measure of the nurse work environment was constructed for each hospital by aggregating nurses' responses to the PES-NWI to the hospital level (Rousseau, 1985; Verran, Gerber, & Milton, 1995). First, the subscale scores were calculated for each hospital as the mean of the items comprising the subscales. The overall PES-NWI score of each hospital was then calculated as the mean of the four subscales used in this study. Furthermore, the PES-NWI score was standardized in the models estimating the effect of nurse work environment on 30-day readmission in the logistic regression models. This allowed me to interpret the results as the expected change in the outcome corresponding with one standard deviation (SD) change in the PES-NWI scores. Using this standardized measure permits comparison of quality of the hospital nursing work environments in cross-sectional studies as well as in longitudinal studies by comparing the percentile of each hospital in terms of their nursing work environment to other hospitals or to itself overtime.

Nurse Staffing. In the Multi-State Nursing Care and Patient Safety Survey, nurses were asked to report the number of patients they cared for during their last shift and the number of registered nurses on their units. Survey responses from nurses who identified themselves as a staff nurse providing direct inpatient care were used to calculate an aggregated measure of hospital nurse staffing. In this study, nurse staffing was presented as the mean number of patients cared for by registered nurses during their last shift for each hospital. This direct measure of hospital nurse staffing is thought to be a better measure of nurse staffing than data from administrative sources that often include nurses not directly involved in inpatient acute care (Aiken, et al., 2002). In addition, the predictive validity of this measure in outcomes research has been demonstrated in previous research (Aiken, Clarke, Cheung, Sloane, & Silber, 2003; Kutney-Lee & Aiken, 2008). Furthermore, this patient-to-nurse ratio measure of nurse staffing is consistent with the measure of nurse staffing by California's nurse staffing mandate.

Nurse education. Nurses provided their education background information in the Multi-State Nursing Care and Patient Safety Survey by answering the question of "what is the highest degree in nursing you hold?" As in previous studies, the proportion of nurses with baccalaureate degrees or above was calculated for each hospital reflecting hospital-level nurse education attainment (Aiken, et al., 2003; Aiken, et al., 2011; Kutney-Lee & Aiken, 2008).

Readmission and 30-day Readmission

In order to accurately identify readmissions, the index admission for each patient should be first identified. The index admission is defined as the hospital stay of the patient for a general, orthopedic or vascular surgery. A patient might have more than one eligible index admission during the study period. In this study, only one randomly selected index admission for each patient was included in the final sample. I used this strategy to avoid inter-patient dependence in statistical tests.

Readmission is the subsequent admission of a patient to a hospital within a defined reference period. The length of the period between index admission and readmission has not been unified; and it can range from one week through to one year. Researchers have used a variety of definitions of readmission in their studies, such as 7-day readmission, 30-day readmission, and 60-day readmission.

In this study, 30-day readmission was used as the primary measure of patient outcome. It was defined as all-cause readmissions to any acute care hospitals within 30 days of discharge from the index admission. I chose this definition of readmission for several reasons. Researchers have shown that the readmission "time-to-event curves" typically stabilized within 30 days of discharge, indicating that a 30-day cutoff is clinically reasonable (Horwitz, et al., 2011). It is the most frequently used definition in readmission research. Thirty-day readmission also has been endorsed by the Centers for Medicare and Medicaid Services as an indicator of hospital care quality. A patient may have more than one readmission within 30 days of discharge of an index admission; only the first readmission was considered as a readmission. However if the patient were readmitted for rehabilitation (diagnosis-related group code of "462"), this readmission was excluded. Once all the eligible 30-day readmissions were identified, a binary variable was created to indicate whether the patient had a readmission within 30 days of discharge from index admission.

In addition to 30-day readmission, other definitions of readmission commonly reported in the literature were reported, including 7-day readmission, 15-day readmission, 21-day readmission, 60-day readmission and 90-day readmission; but only for descriptive purpose.

Hospital structural characteristics for risk adjustment

Hospital ownership, bed size, teaching status, technology level, and location were included in the analysis for risk adjustment. These hospital structural characteristics have been shown to be related to readmissions and other patient outcomes (Ghaferi, et al., 2010; K. E. Joynt & Jha, 2011). Other studies examining the hospital nursing - outcomes relationship have also included these variables for risk adjustment (Aiken, et al., 2003; Aiken, et al., 2011). All information about hospital structural characteristics was obtained from the AHA annual survey.

Ownership. Only adult non-federal acute care hospitals were included in this study; thus hospitals were grouped into two categories regarding their ownership: for profit and not-for-profit.

Bed size. Hospitals were grouped into three categories regarding their number of beds: small hospitals (<=100 beds), medium hospitals (101-250 beds), and large hospitals (>250 beds).

Teaching status. Hospitals were categorized into three groups regarding their teaching status. The trainee-to-bed ratio of each hospital was used to indicate the hospitals' teaching status. Herein, trainees were postgraduate medical residents or fellows. Hospitals without any trainee were considered non-teaching hospitals; hospitals with a 1:4 or smaller trainee-to-bed ratios were minor teaching hospitals; and those with higher than 1:4 trainee-to-bed ratios were major teaching hospitals.

Technology level. Hospitals were considered as either high technology hospitals or non-high technology hospitals in this study. High technology hospitals were those who were capable of providing services of open-heart surgery, organ transplantation, or both.

Location. Based on the Core Based Statistical Area of each hospital, hospitals were considered either urban or rural hospitals.

Patient Characteristics for risk adjustment

Four types of patient characteristics were included for risk adjustment: patient demographics, medical comorbidities, healthcare utilization prior to index admission and surgery type. Patient characteristics are confounding variables for the association between quality of care and patient outcomes (Iezzoni, 1997); and thus, it is necessary to include them for risk adjustment. All of this information was obtained from the patient discharge data.

Patient demographics. Patient demographic data included in this study were: age, gender, and race/ethnicity (white, black, and other).

Medical comorbidities. Risk adjustment for medical comorbidities among the elderly is extremely important given that elder patients often have multiple chronic conditions, which in turn increases their risks for hospital readmissions. The comorbidity risk adjustment approach developed by Elixhauser and colleagues was applied in this study (AHRQ; Elixhauser, et al., 1998). Research has shown that this method has better discrimination than alternative approaches (Southern, Quan, & Ghali, 2004; Stukenborg, Wagner, & Connors Jr, 2001). Two of Elixhauser's comorbidities that are more likely to indicate complications rather than comorbidities were excluded (Glance, Dick, Osler, &

Mukamel, 2006; Quan et al., 2005). The two comorbid conditions were fluid and electrolyte disorders and coagulopathy. A dummy variable was assigned to each comorbid condition indicating whether this comorbidity existed or not for each patient. Comorbidities were identified from the secondary diagnoses of each index admission. Comorbidities information was also withdrawn from the principal and secondary diagnoses of any hospitalizations within 180-day prior to the index admission.

Prior utilization of healthcare. Some researchers have shown that patients with higher prior utilization of healthcare are at increased risk for readmissions; and they suggested that the extent of earlier healthcare utilization should be considered in readmission research. In this study, patients' prior utilization of healthcare was measured by the number of hospital stays within the six months preceding their index admission. A categorical variable was created to indicate patient' prior utilization of healthcare in the six month before the index admission: no hospital stay, one hospital stay, and two or more hospital stays.

Surgery type. Patients undergoing different surgeries may have different risks for readmissions. To avoid a potential confounding effect, dummy variables were created to indicate the specific surgery type each patient underwent. Surgery types were identified using the Diagnosis Related Group (DRG) codes for the index admissions (the used surgical DRGs were listed in Appendix A).

Data Analysis Plan

The following paragraphs describe the data analysis plan in detail. The construction of the analytic dataset is described first, followed by the specific steps of analysis to approach the specific research aims. STATA 12.0 (StataCorp, College Station, TX) and SAS 9.3 (SAS Institute, Cary, NC) were used for data analysis.

Construction of Analytic Dataset

In total four data files were used to construct the analytic dataset: the Multi-State Nursing Care and Patient Safety Survey, AHA annual survey, MedPAR data file, and the BASF data file. Figure 3.1 depicts the data linkage procedure.

The steps in constructing the analytic dataset are described as below:

1. The MedPAR data file and the BASF data file were linked at patient level via the Medicare beneficiary identifier.

2. Index admissions were first identified by applying the inclusion and exclusion criteria.

1) Admissions between July 1, 2006 and June 30, 2007 with the DRGs for general, orthopedic, or vascular surgeries were included.

2) Admissions to acute care hospitals in four study states (CA, FL, NJ, and PA) were included

3) Admissions were included if patients were discharged alive

4) Admissions were included if patients were Medicare fee-for-service enrollees

5) Admissions were included if patients aged 65-89

6) Admissions were excluded if patients were discharged on the same day

7) Admissions were excluded if patients were discharged against medical advice

8) Admissions were excluded if patients were from another acute care hospital

9) Admissions were excluded if patients were transferred to another acute care hospital

10) Admissions were excluded if patients were readmitted for rehabilitation within 30 days from discharge (DRG: “462”).

3. A single surgical admission was randomly selected as index admission for each patient

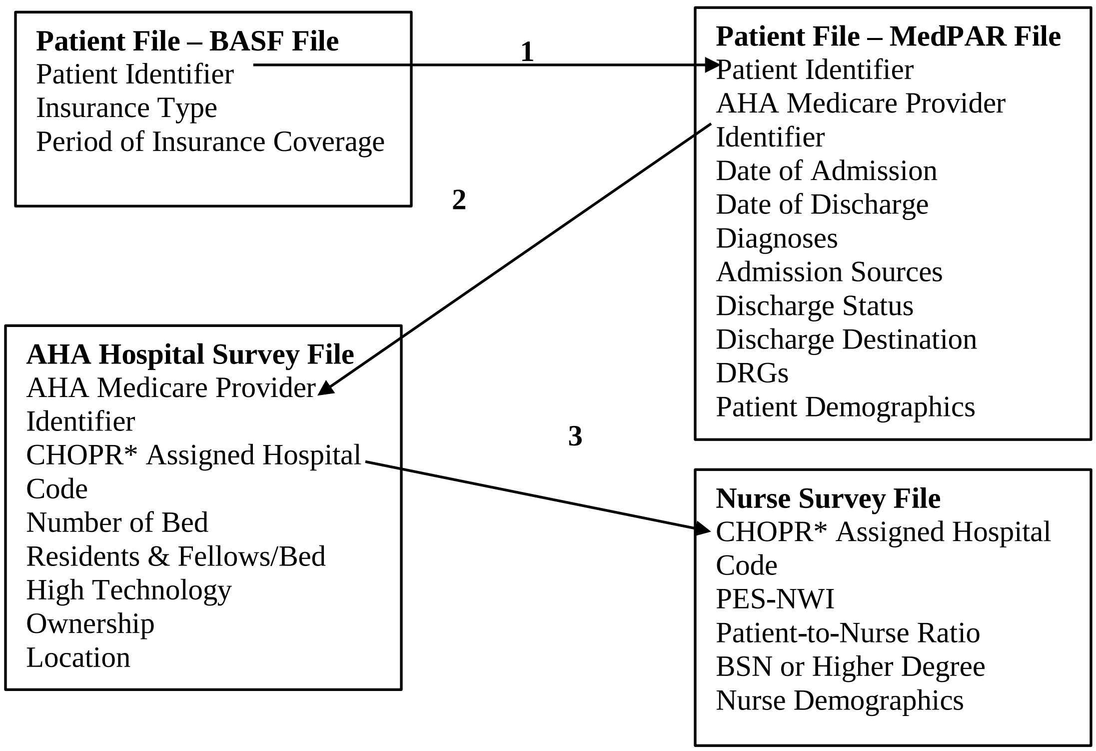
4. Readmissions were identified

5. Patient data file was linked to nurse data file and AHA data file via hospital identifier

6. Hospitals with less than 50 surgeries annually were excluded

Table 3.1 describes the final study sample. Figure 3.2 describes the flow of identifying surgical admissions.

Figure 3.1 Diagram of Data Linkage

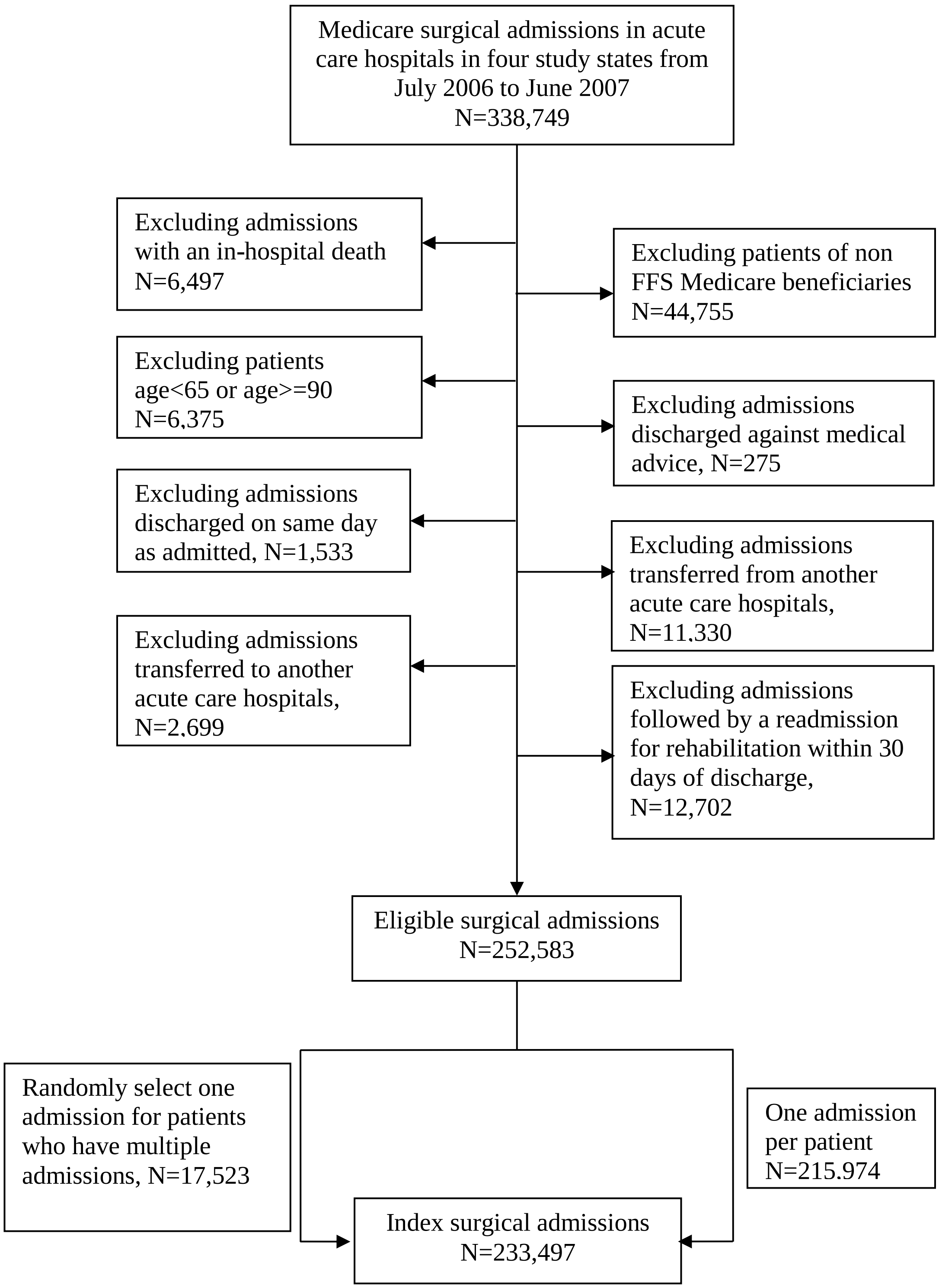


*The Center for Health Outcomes and Policy Research at the University of Pennsylvania

Table 3.1 The Study Sample by State

	ALL N (%)	CA N (%)	FL N (%)	NJ N (%)	PA N (%)
Patients	220,914 (100%)	67,382 (31%)	77,749 (35%)	30,244 (14%)	45,541 (21%)
Nurses	23,090 (100%)	6,738 (29%)	5,019 (22%)	5,074 (22%)	6,259 (27%)
Hospitals	528 (100%)	192 (37%)	135 (26%)	68 (13%)	133 (25%)

Figure 3.2 Flow of Identifying Admissions



Descriptive Analysis of Characteristics of the Study Population

Descriptive statistics were calculated to describe the characteristics of the study population, namely patients, nurses, and hospitals. A description of the patient characteristics was first presented, which included information on patient's demographics, the prevalence of comorbid conditions, and the most frequent diagnoses for index admissions. This was followed by was a description of nurses' demographics. Information of hospital structural characteristics and hospital nursing organization were then presented. Correlations between independent variables at the hospital level were also analyzed and presented, in order to identify any potential risk for multicollinearity. Continuous variables were presented by mean, median, standard deviation, and range. Categorical variable were described by frequency table.

Analysis for Specific Aims and Hypothesis Tests

The purpose of this study is to describe the pattern of surgical readmissions and to investigate the extent to which features of the hospital nursing organization, specifically the hospital nurse work environment, nurse staffing, and nurse education, are associated with 30-day readmissions among Medicare beneficiaries undergoing general, orthopedic, and vascular surgeries.

Specific aim 1: to examine the incidence, variation, and reasons of readmissions within 30 days from discharge among Medicare patients undergoing general, orthopedic, and vascular surgeries

The overall readmission rates and readmission rates by surgery groups (general, orthopedic, and vascular) and states were first calculated and presented to describe the incidence of readmissions among the study patients. The readmissions rates for patients in the 10 largest Diagnosis Related Groups for index admissions and for patients in the 10 Diagnosis Related Groups with highest 30-day readmission rates were also examined and presented. The incidence of readmissions overtime was further explored by conducting Kaplan-Meier survival estimates of readmissions over a period of 90 days after discharge. Unadjusted hospital readmission rates were also calculated and presented.

In order to better understand the causes of readmissions, reasons for 30-day readmissions were described in three different ways. First, the 10 most frequent reasons among all the study patients were identified and presented. Then, the two most frequent reasons for 30-day readmissions were examined and described among patients in the 10 largest Diagnosis Related Groups for index admissions. Finally, the two most frequent reasons for 30-day readmissions were examined and presented among patients in the 10 Diagnosis Related Groups with the highest 30-day readmission rates.

Furthermore, the variations of 30-day readmissions by patient characteristics, hospital characteristics, and hospital nursing organization were examined and described. Both continuous variables and categorical variables were used. Continuous variables were presented by mean, median, standard deviation, and range; and categorical variable were described by frequency table. T-tests, ANOVA tests, and chi-square tests were also applied to examine the differences of interested variables. In addition, Nelson-Aalen Cumulative Hazard Estimates and log-rank tests for equality of survivor functions were used to examine variations of 30-day readmissions by variables of interests.

Specific aim 2: to identify the extent to which hospital nursing organization, specifically nurse work environment, nurse staffing, and nurse education, is associated with 30-day readmissions among Medicare patients undergoing general, orthopedic, and vascular surgeries.

H1: Patients discharged from hospitals with better nurse work environment, lower patient-to-nurse ratio, and higher proportion of nurses with baccalaureate degrees and above are less likely to have a 30-day readmission.

For this hypothesis, the following two sets of logistic regression models were estimated. In all these models, clustering of patients within hospitals was adjusted for using a Huber-White sandwich estimator to adjust the standard errors.

The relationship between the hospital nursing organization, including nurse work environment, nurse staffing, or nurse education, and 30-day readmission was first examined using bivariate regressions. The general form of these bivariate regression models were presented as below:

$$(1)\ \log\left(\frac{p_{\mathrm{ij}}}{1-p_{\mathrm{ij}}}\right) = \alpha_1 + \beta_{\mathrm{N1}} N_{\mathrm{j}}$$

Herein, log is the logit function, p_{ij} is the expected outcome (herein the likelihood of 30-day readmission) for patient i in hospital j, α_1 is a constant, N_j is a vector of hospital nursing organization, β_N is a parameter estimate for N_j

The relationship between hospital nursing organization and 30-day readmissions was further explored in multivariate logistic regression models when controlling for patient characteristics and hospital characteristics. The general form of these multivariate logistics regressions were presented as bellowed:

$$(2)\ \log\left(\frac{p_{\mathrm{ij}}}{1-p_{\mathrm{ij}}}\right) = \alpha_1 + \beta_{\mathrm{N1}} N_{\mathrm{j}} + \beta_{\mathrm{H1}} H_{\mathrm{j}} + \beta_{\mathrm{R1}} R_{\mathrm{ij}}$$

Herein, the terms of p_{ij}, α_1, N_j, and β_N are the same vectors of variables and parameter estimates as in equation (1); and H_j are vectors of hospital characteristics, β_H are parameter estimates for H_j, R_{ij} are vectors of patient risk-adjustment factors, β_R are parameter estimates for Rij.

Human Subjects

All data files are maintained on a secured restricted access server. All the analysis were conducted and stored on a password protected computer. The identifiers assigned to patients in the patient discharge data from CMS have been de-identified and thus were not traceable to the individual patient. The nurse survey only contains pseudo-identification numbers for nurses; nurse respondents are not identifiable by other information too. Hospitals were identified using unique hospital identification numbers and the hospital names were not reported. This study was approved by the Institutional Review Board of the University of Pennsylvania under an exempt review.

CHAPTER 4: RESULTS

Introduction

The purpose of this study was to identify the association between the hospital nursing organization and readmissions in Medicare patients undergoing general, orthopedic, and vascular surgeries. Two specific aims were addressed. *Specific aim 1*: to examine the incidence, variation, and reasons of readmissions within 30 days from discharge in surgical Medicare patients. S*pecific aim 2*: to identify the extent to which the hospital nursing organization, specifically nurse work environment, nurse staffing, and nurse education, is associated with 30-day readmissions in surgical Medicare patients. This chapter first describes the study population, including patients, nurses, and hospitals, followed by the description of the hospital nursing organization. Results from the analyses addressing the specific aims are then provided, including a detailed description of readmissions (incidence and reasons) and their distribution by patient characteristics, hospital characteristics, and hospital nursing organization. It is followed by a description of the association between each study features of hospital nursing organization and 30-day readmissions. Finally, additional analyses are presented to address further inquiries that arose during analysis.

Characteristics of Study Population

Patients

The final study sample included 220,914 Medicare patients who met the study inclusion criteria and underwent general, orthopedic, or vascular surgeries from July 1, 2006 to June 30, 2007 in acute care hospitals in the four study states. Characteristics of the study patients are shown in Table 4.1. The mean age in this group of patients was 76 years (SD=6). There were slightly more female patients (58%) than male patients (42%). The majority of the patients were white (90%). Each patient's comorbidities were identified using diagnostic information from the index admission and admissions 180 days prior to the index admission. The majority of patients had at least one comorbidity (89%) and over 60% had multiple comorbidities. On average, patients in this study population had two comorbidities (SD=1.5) with a range of 0-13. Approximately 21% of the patients had one or more hospitalizations within 180 days prior to the index admission. Roughly half of the patients were hospitalized for orthopedic surgeries.

Figure 4.1 illustrates the distribution of patient age at the index admission. The peak of hospitalizations for general, orthopedic, and vascular surgeries occurred at the age of 70-80. After that, the likelihood for surgeries decreased rapidly as age increased. The distribution of patient age at the index admission by gender and race are displayed in Figures 4.2 and 4.3, respectively. Female patients were more likely to be hospitalized for surgeries at an older age than male patients (Mean: 77 vs. 75; Median: 77 vs. 75; SD: 6 vs. 6). Black patients were more like to be hospitalized at a younger age than Caucasian patients or patients of other races.

Table 4.2 displays the characteristics of study patients by each surgical group (general, orthopedic, and vascular surgeries). Patients hospitalized for vascular surgeries were slightly younger than patients for general and orthopedic surgeries. Patients undergoing general or orthopedic surgeries were more likely to be female (60% and 65%); while patients undergoing vascular surgeries were more likely to be male (61%).

Patients undergoing orthopedic surgeries were more likely to be white (92%). Patients undergoing vascular surgeries were more likely to have comorbidities and admission(s) within 180 days prior to the index admission.

Table 4.1 Characteristics of the Study Patients (N = 220,914)

	N/Mean	**%/SD**
Age (mean, SD)	76.2	6.4
Gender		
Male	93,327	42.3
Female	127,587	57.8
Race/Ethnicity		
White	198,466	89.8
Black	9,536	4.3
Others	12,912	5.8
No. of comorbid conditions†		
0	24,336	11.0
1	59,952	27.1
2-4	122,723	55.6
5 or more	13,903	6.3
No. of admissions within prior 180 days		
0	175,136	79.3
1	32,051	14.5
2 or more	13,727	6.2
Surgical group		
General surgery	60,687	27.5
Orthopedic surgery	108,461	49.1
Vascular surgery	51,766	23.4
No. of comorbid conditions (mean, SD**)**	2.1	1.5
No. of admissions within prior 180 days (mean, SD**)**	0.30	0.71

† This list of comorbidities was based on Elixhauser's comorbidity list. The diagnosis of comorbidities was based on the secondary diagnoses of index admission as well as both the primary and secondary diagnosis of any admission in 180 days prior to index admissions. The HCUP comorbidity software version 3.2 was used for analysis.

Figure 4.1 Distribution of Patient Age at Index Admission

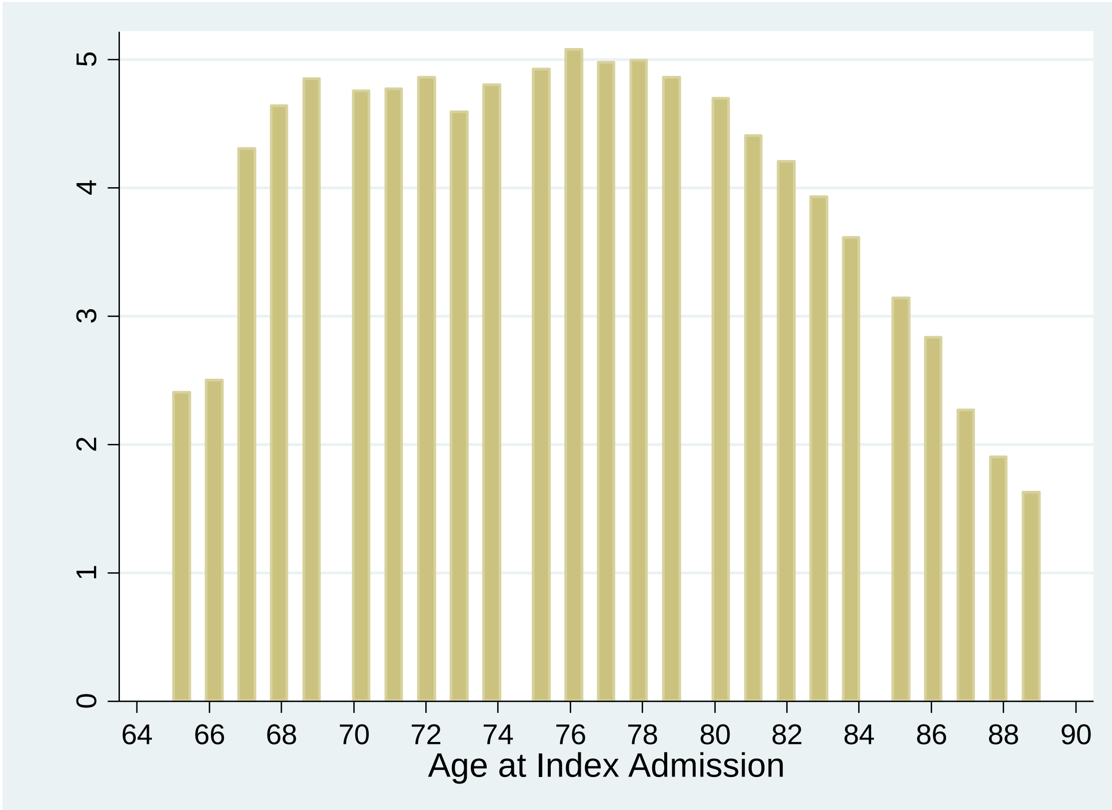


Figure 4.2 Distribution of Patient Age at Index Admission by Gender

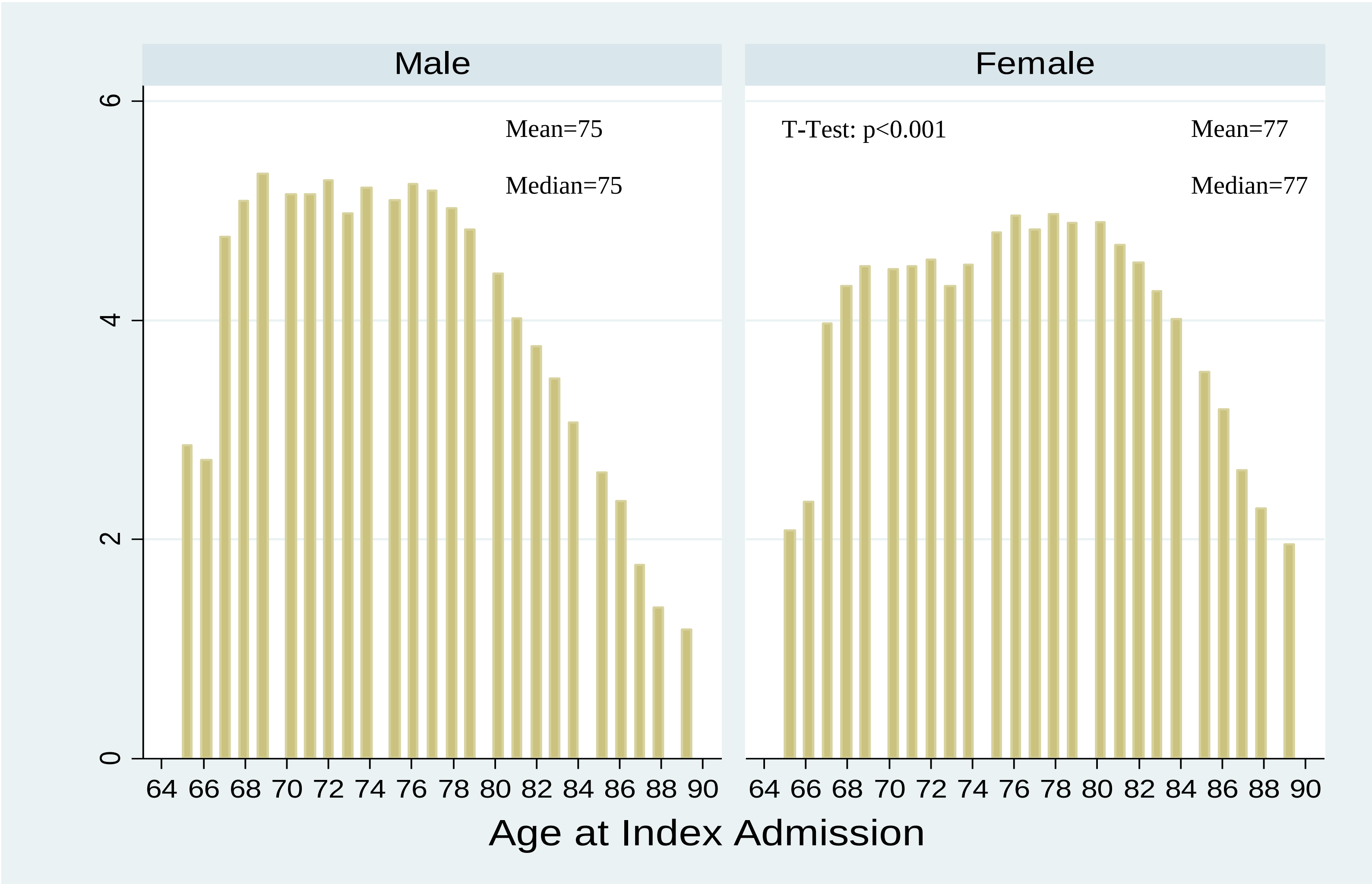


Figure 4.3 Distribution of Patient Age at Index Admission by Race/Ethnicity

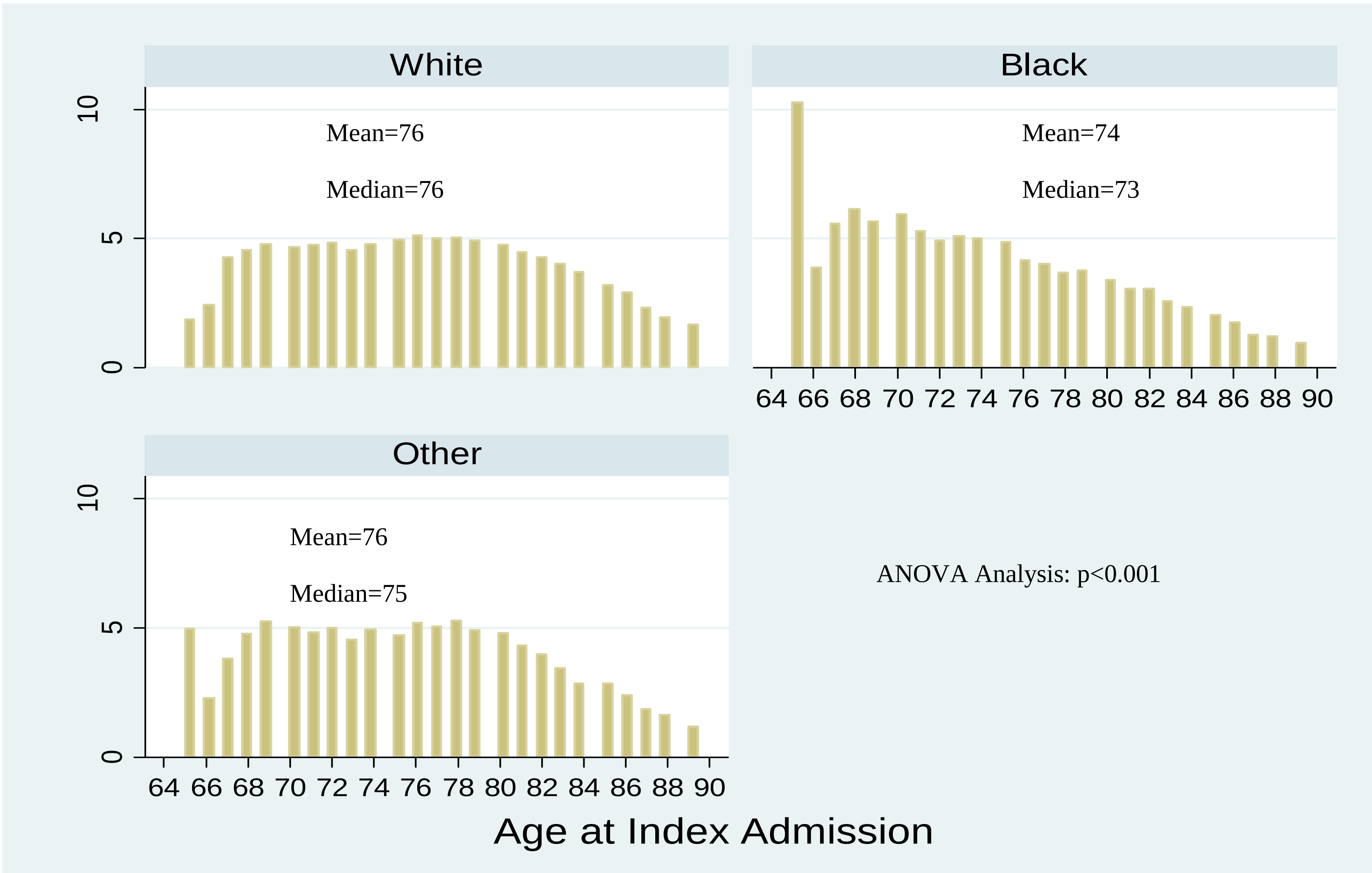


Table 4.2 Characteristics of the Study Patients by Surgery Group (N=220,914)

	General (N=60,687)		**Orthopedic (N=108,461)**		**Vascular (N=51,766)**	
	N	**%**	**N**	**%**	**N**	**%**
Age (Mean, SD)**	76.1	6.4	76.55	6.3	75.42	6.3
Gender* **						
Male	24,209	39.9	37,521	34.6	31,597	61.0
Female	36,478	60.1	70,940	65.4	20,169	39.0
Race* **						
White	53,211	87.7	99,787	92.0	45,468	87.8
Black	3,338	5.5	3,506	3.2	2,692	5.2
Others	4,138	6.7	5,168	4.8	3,606	7.0
No. of comorbid conditions†* **						
0	7,233	11.9	12,844	11.8	4,259	8.2
1	16,156	26.6	31,092	28.7	12,704	24.5
2-4	33,193	54.7	59,398	54.8	30,132	58.2
5 or more	4,105	6.8	5,127	4.7	4,671	9.0
No. of admissions within prior 180 days* **						
0	45,924	75.7	91,389	84.3	37,823	73.1
1	10,240	16.9	12,537	11.6	9,274	17.9
2 or more	4,523	7.5	4,535	4.2	4,669	9.0
No. of comorbid conditions (mean, SD)* **	2.1	1.5	2.0	1.4	2.3	1.5
No. of admissions within prior 180 days (mean, SD)* **	0.36	0.76	0.22	0.60	0.41	0.84

**p<0.01, ***p<0.001; †Based on the secondary diagnoses of index admissions and both the primary and secondary diagnoses of admissions within prior 180 days of index admission; the Elixhauser comorbidity list was used to identify patient comorbidities.

The 10 most frequent reasons (Diagnosis Related Groups, DRGs) for index admissions are listed in Table 4.3. In total, patients hospitalized with any of these 10 DRGs consisted of 75% of the study patients, and orthopedic surgeries accounted for five of the 10 listed DRGs. The most frequent reason for hospitalization in this study was major joint replacement or reattachment of the lower extremity surgeries, such as hip or knee replacement. Approximately one in four of the 220,914 patients (24%) in this study were hospitalized for major joint replacement of the lower extremity surgeries. The second most frequent reason for hospitalization was percutaneous cardiovascular procedures (19%).

Table 4.4 displays the prevalence of comorbid conditions among the study patients. Overall, the presence of comorbid conditions ranged from 68% (hypertension) to 0.02% (acquired immune deficiency syndrome, AIDS). The five most frequent comorbidities were hypertension (68%), diabetes (24%, both uncomplicated and complicated), chronic pulmonary disease (18%), deficiency anemia (14%), and hypothyroidism (13%). The prevalence of comorbid conditions in each surgical group (general, orthopedic, and vascular) is presented in Table 4.5. The presence of each comorbid condition varied by surgical group.

Table 4.3 The Ten Most Frequent Reasons (DRGs) for Index Admissions (N=220,914)

	N	**%**
Major joint replacement of lower extremity	53,795	24.4
Percutaneous cardiovascular procedures	40,842	18.5
Major small and large bowel procedures	15,934	7.2
Hip and femur procedures except major joint	12,814	5.8
Laparoscopic cholecystectomy with CDE	10,626	4.8
Back and neck procedures except spinal fusion	10,194	4.6
Major cardiovascular procedures	7,017	3.2
Spinal fusion	5,870	2.7
Lower extremity and humerus procedure except hip, foot, femur	5,610	2.5
Hernia procedures except inguinal & femoral	3,348	1.5
Total	166,050	75.1

CDE, common duct exploration

Table 4.4 Comorbidities of the Study Patients (N=220,914)

	N	**%**
Hypertension	149,452	67.7
Diabetes, uncomplicated	45,379	20.5
Chronic pulmonary disease	40,602	18.4
Deficiency anemia	31,013	14.0
Hypothyroidism	29,437	13.3
Valvular disease	22,830	10.3
Congestive heart failure	21,331	9.7
Renal failure	18,935	8.3
Peripheral vascular disorders	17,966	8.1
Obesity	13,583	6.2
Depression	13,176	6.0
Other neurological disorders	11,348	5.1
Diabetes, complicated	7,848	3.6
Rheumatoid arthritis/collagen vascular disease	6,422	2.9
Metastatic cancer	5,891	2.7
Blood loss anemia	5,502	2.5
Solid tumor without metastasis	4,608	2.1
Weight loss	3,765	1.7
Pulmonary circulation disorders	3,437	1.6
Psychoses	2,683	1.2
Alcohol abuse	2,660	1.2
Liver disease	2,394	1.1
Paralysis	2,228	1.0
Lymphoma	1,385	0.6
Drug abuse	526	0.2
Peptic ulcer disease, excluding bleeding	134	0.06
Acquired immune deficiency syndrome (AIDS)	47	0.02

This list of comorbidities was based on Elixhauser's comorbidity list. The diagnosis of comorbidities was based on the secondary diagnoses of index admission as well as both the primary and secondary diagnosis of any admission in180 days prior to the index admissions. The HCUP comorbidity software version 3.2 was used for analysis.

Table 4.5 Comorbidities of Study Patients by Surgical Groups (General, Orthopedic, and Vascular) (N=220,914) (Continued on next page)

	General (N=60,687)		**Orthopedic (N=108,461)**		**Vascular (N=51,766)**	
	N	**%**	**N**	**%**	**N**	**%**
Hypertension	37,765	62.2	73,145	67.4	38,542	74.5
Diabetes, uncomplicated	11,783	19.4	19,783	18.2	13,813	26.7
Chronic pulmonary disease	12,156	20.0	18,341	16.9	10,105	19.5
deficiency anemia	7,792	12.8	18,362	16.9	4,859	9.4
Hypothyroidism	7,432	12.3	16,989	15.7	5,016	9.7
Valvular disease	5,856	9.7	9,337	8.6	7,637	14.8
Congestive heart failure	6,494	10.7	7,075	6.5	7,762	15.0
Renal failure	5,083	8.4	5,890	5.4	7,422	14.3
Peripheral vascular disorders	3,820	6.3	4,693	4.3	9,453	18.3
Obesity	3,327	5.5	7,059	6.5	3,197	6.2
Depression	3,057	5.0	8,300	7.7	1,819	3.5
Other neurological disorders	2,765	4.6	6,891	6.4	1,692	3.3
Diabetes, complicated	2,235	3.7	2,687	2.5	2,926	5.7
Rheumatoid arthritis/collagen vascular disease	1,451	2.4	3,967	3.7	1,004	1.9
Metastatic cancer	4,994	8.2	648	0.6	249	0.5
Blood loss anemia	2,240	3.7	2,537	2.3	725	1.4

Solid tumor without metastasis	2,314	3.8	1,353	1.3	941	1.8
Weight loss	2,290	3.8	972	0.9	503	1.0
Pulmonary circulation disorders	1,048	1.7	1,259	1.2	1,130	2.2
Psychoses	768	1.3	1,506	1.4	409	0.8
Alcohol abuse	819	1.4	1,298	1.2	543	1.1
Liver disease	1,340	2.2	745	0.7	309	0.6
Paralysis	636	1.1	1,127	1.0	465	0.9
Lymphoma	455	0.8	654	0.6	276	0.5
Drug abuse	158	0.3	278	0.3	90	0.2
Peptic ulcer disease, excluding bleeding	58	0.10	55	0.05	21	0.04
Acquired immune deficiency syndrome (AIDS)	12	0.02	13	0.01	22	0.04

This list of comorbidities was based on Elixhauser's comorbidity list. The diagnosis of comorbidities was based on the secondary diagnoses of the index admission as well as the principal and secondary diagnoses of any admission in 180 days prior to index admissions. The HCUP comorbidity software version 3.2 was used for analysis.

Nurses

A total of 23,090 nurses in the study hospitals that met the inclusion criteria were included. The characteristics of these nurses are described in Table 4.6. The average age of the study nurses was 44 years old (SD=11) with an average of 17-year working experience as an RN (SD=11). The majority of nurses were female (93%) and white (77%). Approximately 43% of the nurses had a bachelor's degree or above. Roughly one in four of the nurses work in intensive care units.

Hospitals

The characteristics of the 528 study hospitals are presented in Table 4.7. The majority of the hospitals were not-for-profit (81%) hospitals. Very few hospitals were small hospitals (10%) with 100 beds or less or were located in rural areas (10%). Hospitals were evenly distributed between teaching (minor or major) and non-teaching hospitals, as well as between high technology hospitals providing open-heart surgery and/or organ transplantation and hospitals not providing these services.

Table 4.6 Characteristics of the Study Nurses (N=23,090)

	N/Mean	**%/SD**
Age (mean, SD)	44.3	10.8
Years as a RN (mean, SD)	16.5	11.2
Gender		
Female	21,396	93.1
Male	1,588	6.9
Race/Ethnicity		
White	17,381	77.2
Black	1,017	4.5
Filipino	2,201	9.8
Others	1,917	8.5
Highest nursing degree		
Diploma	4,122	18.8
Associate degree	8,437	38.4
Baccalaureate degree	8,706	39.7
Master or Doctoral degree	684	3.1
Unit specialty		
Med/Surg	3,606	16.2
ICU	5,014	22.6
Operating/recovery room	2,398	10.8
Others	11,180	50.3

Note: Total may not be equal to 23,090 due to missing data. Percentages may not be equal to 100% due to rounding.

Table 4.7 Distribution of Hospital Structural Characteristics (N=528)

	N	**%**
Ownership		
Not for profit	425	80.5
For profit	103	19.5
Bed size		
Small (<=100)	55	10.4
Medium (101-250)	232	43.9
Large (>=251)	241	45.6
Teaching status		
Non-teaching	271	51.3
Minor	215	40.7
Major	42	8.0
Technology level		
Not high tech	278	52.7
High tech	250	47.4
Location		
Rural	52	9.9
Urban	476	90.2

Notes: Hospital teaching status was defined based on the trainee-to-bed ratios of each hospital. Hospitals with trainee-to-bed ratio of “0” were non-teaching hospitals; hospitals with trainee-to-bed ratio of 0.25 or less were minor teaching hospitals; hospitals with trainee-to-bed ratio of more than 0.25 were major teaching hospitals.

High technology hospitals were those that provide services of open-heart surgery, organ transplantation, or both.

Urban hospitals were identified according to their Core Based Statistical Area (CBSA) type, either division or macro.

Percentages may not be equal to 100% due to rounding.

Hospital Nursing Organization

Three characteristics of the hospital nursing organization were studied: nurse work environment, nurse staffing, and nurse education. These characteristics of the hospital nursing organization are displayed in Table 4.8. The Practice Environment Scale of the Nursing Work Index (PES-NWI) measured the quality of the nurse work environment and averaged 2.7 on a 4-point scale (SD=0.23). The average scores of the five subscales of PES-NWI ranged from 2.4 on staffing and resource adequacy to 2.9 on nursing foundation for quality of care. On average, each nurse cared for approximately 5 patients on their last shift (SD=1). The average percentage of nurses with bachelor degrees in nursing or above among the study hospitals was 38% (SD=0.13).

Table 4.9 presents the distribution of hospital nursing organization. Overall, the largest proportion of hospitals had nurse work environments with PES-NWI scores of 2.72-2.94 (35%), which is within one SD above the mean, a patient-to-nurse ratio of 5:1 (33%), and 40% or more of their nurses prepared at baccalaureate level or above (43%).

Table 4.8 Characteristics of Hospital Nursing Organization (N=528)

	Mean	SD	Median	Range
PES-NWI	2.72	0.23	2.72	2.15-3.42
Nurse participation in hospital affairs	2.52	0.30	2.50	1.73-3.37
Foundations for quality of care	2.91	0.22	2.92	2.20-3.54
Nurse manager ability, leadership, and support of nurses	2.56	0.29	2.54	1.71-3.64
Collegial nurse-physician relations	2.87	0.22	2.88	2.08-3.54
Staffing and resource adequacy	2.44	0.32	2.43	1.48-3.56
Nurse staffing	5.13	1.31	4.97	2.50-11.00
Nurse education	0.38	0.14	0.37	0.00-0.75

PES-NWI: Practice Environment Scale of the Nursing Work Index, calculated as the mean of the four subscales used in this study
The subscale measuring staffing and resource adequacy was not included in calculating the PES-NWI score for further analysis because of its high correlation with the direct measure of nurse staffing.

Table 4.9 Distribution of Hospital Nursing Organization (N=528)

	N	%
PES-NWI		
One SD below mean	87	16.5
Within 1 SD below mean	173	32.8
Within 1 SD above mean	184	34.9
One SD above mean	84	15.9
Nurse staffing		
<=4 patients per nurse	96	18.2
5 patients per nurse	175	33.1
6 patients per nurse	142	26.9
>=7 patients per nurse	115	21.8
Nurse education		
<=20% with BSN or above	51	9.7
>20% and <=30%	98	18.6
>30% and <=40%	151	28.6
>40%	228	43.2

PES-NWI score was standardized, which indicates that one unit change in the standardized PES-NWI score equals on standard deviation (0.23) change in the raw PES-NWI score.

Table 4.10 summarizes hospital structural and nursing characteristics of the 528 study hospitals, and displays the distribution of patients and nurses by these hospital characteristics. A detailed description of hospital characteristics has been presented above in Tables 4.7 and 4.9. Table 4.10 shows that there were proportionately more patients and nurses in larger, high technology, urban hospitals, when compared to the proportion of hospitals in each type.

The correlation matrix of independent variables of the hospital nursing organization and hospital structural characteristics is presented in Table 4.11. The three features of the hospital nursing organization – nurse work environment, nurse staffing, and nurse education– were moderately or weakly correlated (environment and staffing: $r = -0.38$; environment and education: $r = 0.20$; and staffing and education: $r = -0.32$). The subscales of PES-NWI were highly and significantly intercorrelated, suggesting that it would be inappropriate to include them in one analytical model simultaneously. The Staffing and Resource Adequacy subscale was omitted to calculate the PES-NWI score for each hospital. This is because, conceptually and empirically, this subscale overlaps with the direct measure of nursing staffing. In this study, a correlation coefficient of -0.50 was found between the Staffing and Resource Adequacy subscale and nurse-reported staffing. The correlations among hospital structural characteristics were either weak or moderate. Similarly, the correlations between the hospital nursing organization and hospital structural characteristics were weak; although some of them were significant.

Table 4.10 Distribution of the Study Population (Patients, Nurses, and Hospitals) by Hospital Structural and Nursing Characteristics

	Patient (220,914) N (%)	**Nurse (23,090) N (%)**	**Hospital (528) N (%)**
Ownership			
Not for profit	184,684 (83.6)	20,622 (89.3)	425 (80.5)
For profit	36,230 (16.4)	2,468 (10.7)	103 (19.5)
Bed size			
Small (<=100)	7,892 (3.6)	852 (3.7)	5 (10.4)
Medium (101-250)	61,896 (28.0)	6,443 (27.9)	232 (43.9)
Large (>=251)	151,126 (68.4)	15,795 (68.4)	241 (45.6)
Teaching status			
Non-teaching	105,564 (47.8)	9,733 (42.1)	271 (51.3)
Minor	92,003 (41.7)	9,673 (41.9)	215 (40.7)
Major	23,347 (10.6)	3,695 (16.0)	42 (8.0)
Technology level			
Not high tech	66,895 (30.3)	8,255 (35.8)	278 (52.7)
High tech	154,019 (69.7)	14,835 (64.3)	250 (47.4)
Location			
Rural	11,026 (5.0)	1,070 (4.6)	52 (9.9)
Urban	209,888 (95.0)	22,020 (95.4)	476 (90.2)
PES-NWI			
1 SD below mean	22,239 (10.1)	2,474 (10.7)	85 (16.1)
Within 1 SD below mean	68,850 (31.2)	6,946 (30.1)	179 (33.9)
Within 1 SD above mean	83,327 (37.7)	9,135 (39.6)	176 (33.3)
1 SD above mean	46,498 (21.1)	4,535 (19.6)	88 (16.7)
Nurse staffing			
<=4 patients per nurse	81,675 (37.0)	4,499 (19.5)	133 (25.2)
5 patients per nurse	83,386 (37.8)	9,441 (40.9)	179 (33.9)
6 patients per nurse	40,741 (18.4)	5,726 (24.8)	118 (22.4)
>=7 patients per nurse	15,112 (6.8)	3,424 (14.8)	98 (18.6)
Nurse education			
<=20% with BSN or above	11,211 (5.1)	1,194 (5.2)	40 (7.6)
>20% & <=30%	43,706 (19.8)	3,572 (15.5)	112 (21.2)
>30% & <=40%	63,789 (28.9)	6,443 (27.9)	145 (27.5)
>40%	102,208 (46.3)	11,881 (51.5)	231 (43.8)

Table 4.11 Pearson Correlations between Hospital Structural Characteristics and Nurse Organization, Hospital Level (N=528)

	1	2	3	4	5	6	7	8	9	10	11	12
1. Nurse work environment												
2. Nurse participation in hospital affairs	0.92^{***}											
3. Foundations for quality of care	0.93^{***}	0.88^{***}										
4. Nurse manager ability, leadership, and support of nurses	0.88^{***}	0.74^{***}	0.76^{***}									
5. Collegial nurse-physician relations	0.74^{***}	0.53^{***}	0.60^{***}	0.53^{***}								
6. Staffing and resource adequacy	0.78^{***}	0.67^{***}	0.72^{***}	0.71^{***}	0.60^{***}							
7. Nurse staffing	-0.38^{***}	-0.32^{***}	-0.38^{***}	-0.30^{***}	-0.33^{***}	-0.50^{***}						
8. Nurse education	0.20^{***}	0.19^{***}	0.20^{***}	0.14^{**}	0.19^{***}	0.19^{***}	-0.32^{***}					
9. Bed size	0.11^{*}	0.14^{**}	0.19^{***}	0.04	0.01	0.01	-0.19^{***}	0.27^{***}				
10. Teaching status	0.09^{*}	0.11^{*}	0.12^{*}	0.01	0.11^{*}	0.08	-0.17^{***}	0.26^{***}	0.37^{***}			
11. Ownership	-0.22^{***}	-0.23^{***}	-0.28^{***}	-0.09^{*}	-0.19^{***}	-0.23^{***}	0.10^{*}	-0.05	-0.17^{***}	-0.13^{**}		
12. Technology status	0.14^{**}	0.16^{**}	0.19^{***}	0.07	0.08	0.09^{*}	-0.26^{***}	0.19^{***}	0.47^{***}	0.26	0.00	
13. Location	0.10^{*}	0.07	0.14^{**}	0.07	0.09^{*}	-0.00	-0.23^{***}	0.23^{***}	0.25^{***}	0.10^{*}	0.07	0.25^{***}

* $p<0.05$, ** $p<0.01$, *** $p<0.001$; weak correlation if correlation coefficient is -0.3 - 0.3; moderate correlation if correlation coefficient is -0.6 - -0.3 or 0.3 - 0.6; strong correlation if correlation coefficient is -1 - -0.6 or 0.6 - 1.0

Specific Aim 1

Specific Aim 1: To describe the incidence, variation, and reason of readmissions within 30 days from discharge in Medicare patients undergoing general, orthopedic, and vascular surgeries.

Readmissions

Table 4.12 describes the cumulative percentage of readmissions by 30 days from discharge in the study patients, overall and by states. It also presents the cumulative percentage of readmissions by 7, 15, 21, 60, and 90 days after discharge, in order to better understand the trends of readmissions over time. Roughly 10% of the patients were readmitted within 30 days from discharge. The cumulative percentage of readmissions increased from 4% at 7 days to 17% at 90 days at a declining rate. Patients discharged from hospitals in California had the lowest cumulative proportion of readmissions by the end of each period, while patients discharged from hospitals in New Jersey had the highest cumulative proportion of readmissions by the end of each period.

The cumulative percentage of readmissions by 7, 15, 21, 30, 60, and 90 days after discharge for each surgical group (general, orthopedic, and vascular) are presented in Table 4.13. Among the three groups, patients hospitalized for vascular surgeries had the highest cumulative proportion of readmissions by the end of each period, while patients hospitalized for orthopedic surgeries had the lowest cumulative proportion of readmissions by the end of each period.

Table 4.12 Readmissions Following Surgical Discharges from Hospitals in the Study Patients (N=220,914)

	Cumulative Readmissions by the End of Period									
	All (N=220,914)		**CA (N=67,380)**		**FL (N=77,749)**		**NJ (N=30,244)**		**PA (N=45,541)**	
Interval after Discharge	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
0-7 days ***	7,962	3.6	2,179	3.2	2,745	3.5	1,313	4.3	1,725	3.8
8 - 15 days***	13,678	6.2	3,781	5.6	4,708	6.1	2,264	7.5	2,925	6.4
16 - 21days***	16,917	7.7	4,646	6.9	5,747	7.5	2,806	9.3	3,618	7.9
22 - 30 days***	20,887	9.5	5,663	8.4	7,232	9.3	3,482	11.5	4,510	9.9
31 - 60 days***	30,431	13.8	8,242	12.2	10,477	13.5	5,064	16.7	6,648	14.6
61 - 90 days***	37,398	16.9	10,192	15.1	12,841	16.5	6,151	20.3	8,214	18.0

***p<0.001

Table 4.13 Readmissions Following Surgical Discharges from Hospitals in Study Patients by Surgical Group (N=220,914)

	Cumulative Readmissions by the End of Period					
	General (N=60,687)		**Orthopedic (N=108,461)**		**Vascular (N=51,766)**	
Interval after Discharge	**N**	**%**	**N**	**%**	**N**	**%**
0-7 days***	2,633	4.3	2,945	2.7	2,384	4.6
8 - 15 days***	4,342	7.2	5,257	4.9	4,079	7.9
16 - 21days***	5,242	8.6	6,597	6.1	5,078	9.8
22 - 30 days***	6,375	10.5	8,215	7.6	6,297	12.2
31 - 60 days***	9,023	17.9	12,030	11.1	9,378	18.1
61 - 90 days***	11,009	18.1	14,885	13.7	11,504	22.2

***p<0.001

Considering readmissions as failure events, the Kaplan-Meier survival estimate and the Nelson-Aalen cumulative hazard estimate for readmission over 90 days are displayed in Figures 4.4 and 4.5. The hazard for readmissions decreased at a declining rate when the interval between discharge and readmission extended. The occurrence of readmissions appeared to stabilize after approximately 30 days.

Table 4.14 shows the 10 most frequent reasons (DRGs) for 30-day readmissions in study patients. Heart failure was the most frequent DRG for 30-day readmissions and accounted for 4.5% of the 20,887 readmissions. It is followed by esophagitis, gastroenteritis and miscellaneous disorders, and postoperative infections. Each of these accounted for 4.1% of all readmissions within 30 days from discharge. In total, these 10 DRGs added up to 6,557 30-day readmissions or 31%.

Table 4.15 displays 30-day readmissions rates of the 10 largest DRGs for index admissions and the two most frequent reasons (DRGs) for readmissions in these DRGs (more details about these 10 largest DRGs for the index admission have been presented in Table 4.4). On average, patients in these 10 largest DRGs for index admissions had a 30-day readmission rate of 9%. Their 30-day readmissions accounted for 71% of the total readmissions within 30 days from discharge in this study. Infections, particularly postoperative infections, were a very common reason for 30-day readmissions.

Figure 4.4 Kaplan-Meier Survival Estimates of Readmissions over 90 Days Following Discharge

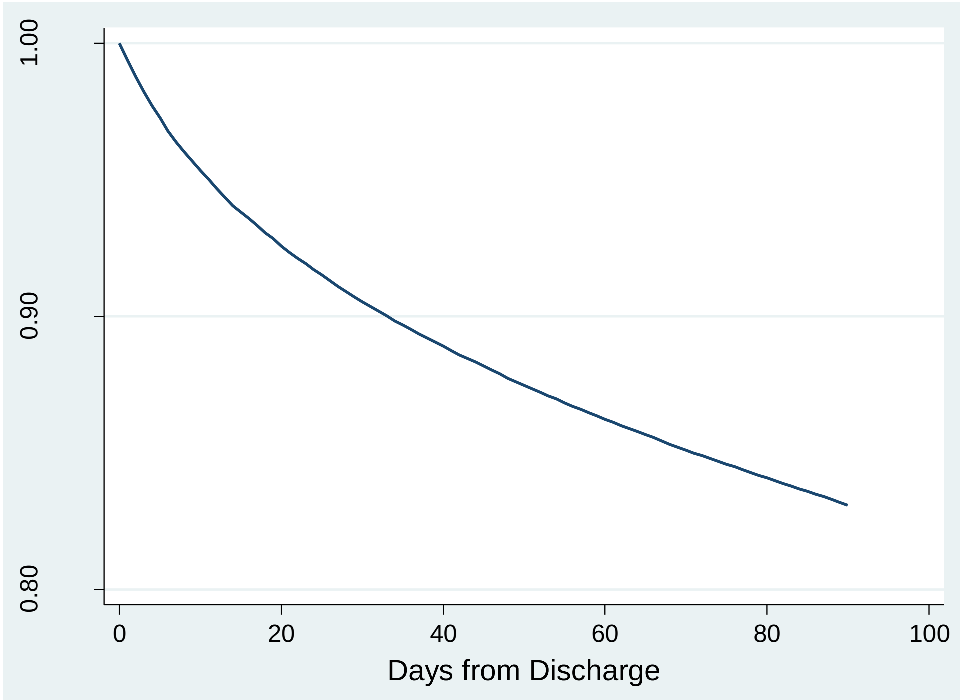


Figure 4.5 Smoothed Hazard Estimates of Readmissions over 90 Days Following Discharge

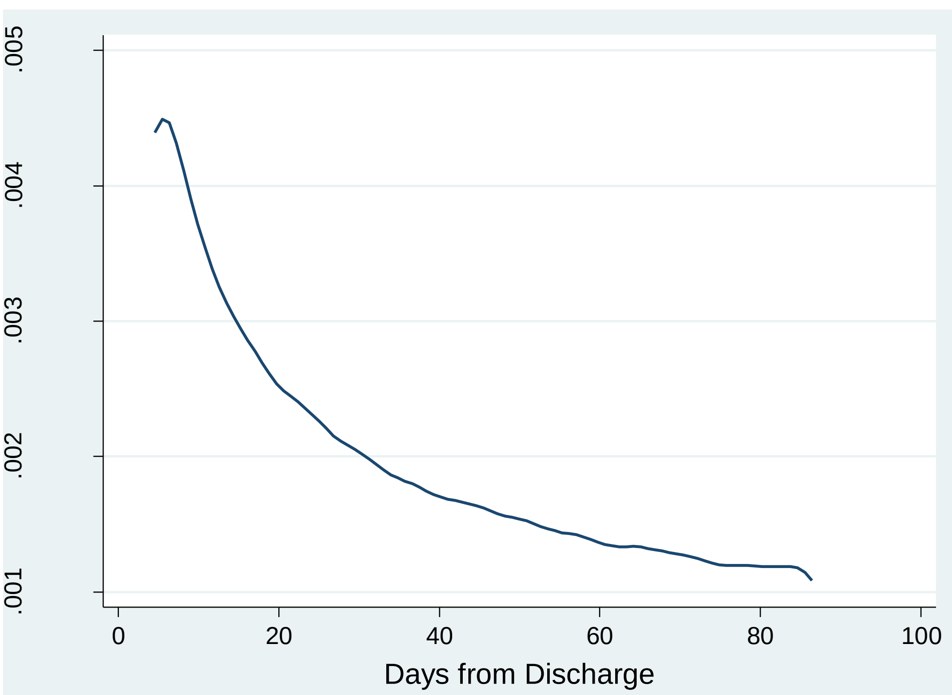


Table 4.14 The Ten Most Frequent Reasons (DRGs) for 30-Day Readmissions in Study Patients (Number of total 30-day readmissions: 20,887)

Readmission DRG Title	Number of 30-day Readmissions	%
Heart Failure	932	4.5
Esophagitis, gastroenteritis and miscellaneous disorders	865	4.1
Postoperative and post-traumatic infections	860	4.1
Gastrointestinal hemorrhage	671	3.2
Cardiac arrhythmia and conduction disorders	617	3.0
Other digestive diagnosis	590	2.8
Renal failure	508	2.4
Operating procedure for infections	506	2.4
Simple pneumonia and pleurisy	505	2.4
Complications of treatment	503	2.4
Total	6,557	31.4

Table 4.15 Thirty-Day Readmission Rates and the Two Most Frequent Reasons for 30-Day Readmissions in the Largest Diagnosis Related Groups for Index Admissions

DRG at Index Admission	**30-day Readmission Rate**	**Most Frequent (%)**	**2nd Most Frequent (%)**
Major joint replacement	6.2	Revision of hip or knee replacement (5.5)	Aftercare (5.2)
Percutaneous cardiovascular procedures	11.0	Cardiac stent (11.84)	Heart Failure (7.2)
Major bowel procedures	12.7	Other digestive diagnoses (9.8)	Postoperative infections (8.2)
Hip and femur procedures except major joint	11.1	Kidney and urinary infections (5.1)	Septicemia (4.9)
Laparoscopic cholecystectomy with CDE	7.9	Esophagitis, gastroenteritis and miscellaneous disorders (11.5)	Disorder of the biliary tract (4.5)
Back and neck procedures except spinal fusion	6.1	Operating procedure for infections (8.9)	Postoperative infections (6.8)
Major cardiovascular procedures	13.3	Heart Failure (7.3)	Postoperative infections (5.0)
Spinal fusion	7.9	Operating procedure for infections (12.1)	Postoperative infections (6.5)
Lower extremity and humerus procedure except hip, foot, femur	8.0	Lower extremity and humerus procedures (9.6)	Postoperative infections (5.8)
Hernia procedures except inguinal& femoral	7.6	Postoperative infections (11.1)	Other digestive diagnoses (8.3)

The conditions for index admission are listed in order of decreasing total number of index admissions. The diagnosis related group (DRG) numbers for the conditions for index admission are listed in **Table 4. 4**. The diagnosis related group (DRG) numbers listed for readmissions are as follows: revision of hip or knee replacement: 545; aftercare: 249; cardiac stent: 557, 558; heart failure: 127; other digestive diagnoses: 188; postoperative infections: 418; kidney and urinary infections: 320; septicemia: 416; esophagitis, gastroenteritis and miscellaneous digestive disorders: 182; disorder of the biliary tract: 207; operating procedure for infections: 415; lower extremity and humerus procedures: 218

Table 4.16 describes the 10 DRGs with the highest 30-day readmission rates. One in four of the Medicare patients (26%) undergoing surgeries for upper limb & toe amputation for circulatory system disorders were readmitted. For the five DRGs with a readmission rate of higher than 20%, three were DRGs for vascular surgeries. The two most frequent reasons (DRGs) for 30-day readmissions in the DRGs with highest 30-day readmission rates are displayed in Table 4.17.

Table 4.18 displays the unadjusted readmission rates in study hospitals within 7, 15, 21, 30, 60, and 90 days from discharge. Overall, hospital readmission rates increased at a declining rate as time (days) from discharge extended. Hospital readmissions distributed slightly right skewed; and the skewness decreased when time (days) from discharge extended. Figure 4.6 illustrates the distribution of unadjusted 30-day readmission rates at the hospital level.

Table 4.16 The Ten Diagnosis Related Groups with the Highest 30-day Readmission Rates

DRG Title	Number of Patients	Number of 30-day Readmissions	%
Upper limb & toe amputation for circulatory system disorders	384	100	26.0
Other hepatobiliary or pancreas operating procedures	101	26	25.7
Amputation for circulatory system disorders except upper limb & toe	1,324	296	22.4
Other circulatory system operating procedures	2,106	448	21.3
Other endocrine, nutritional and metabolic disease operating procedures	608	127	20.6
Other digestive system operating procedures	1,451	286	19.7
Skin grafts and wound debrid for endocrine, nutritional and metabolic disorders	291	54	18.6
Hepatobiliary diagnostic procedure for non-malignancy	73	13	17.8
Amputation for musculoskeletal system and connective tissues disorders	364	62	17.0
Pancreas, liver & shunt procedures	1,201	203	16.9

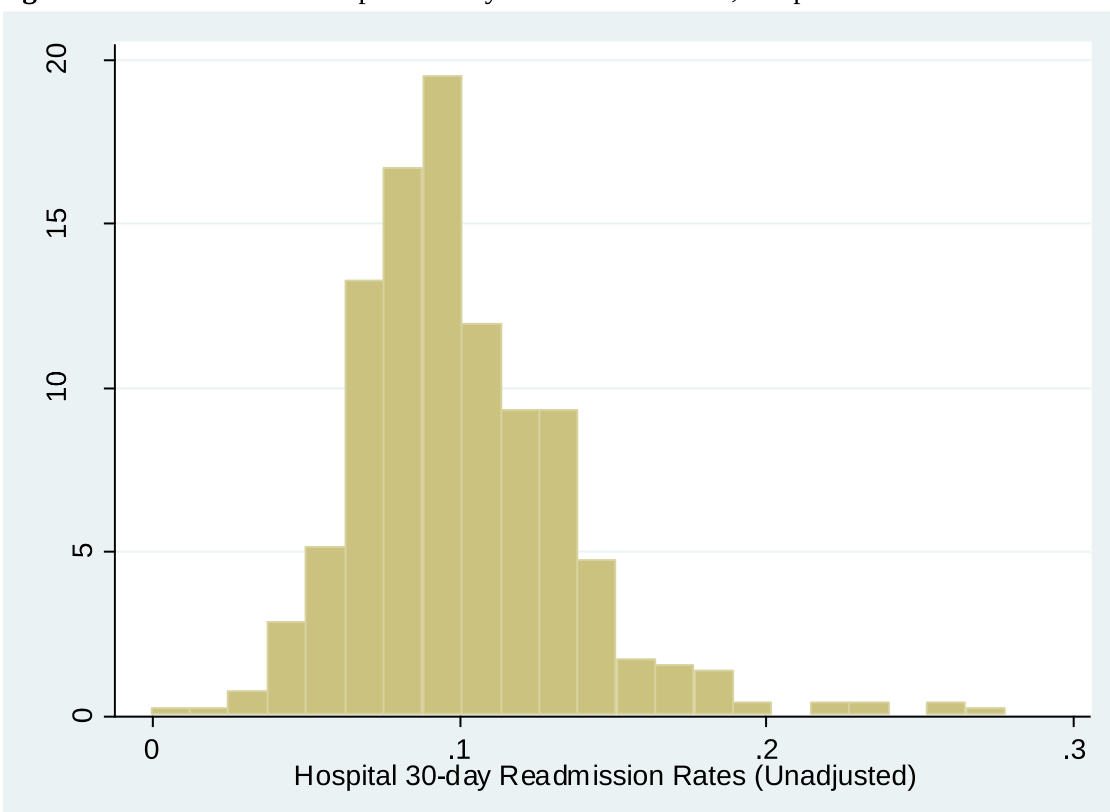
Table 4.17 The Two Most Frequent Reasons for 30-day Readmissions in the Ten Diagnosis Related Groups with the Highest 30-day Readmission Rates

DRG at Index Admission	30-day Readmission rate	Most Frequent (%)	2nd Most Frequent (%)
Upper limb & toe amputation for circulatory system disorders	26.0	Amputation: circulartory system disorders (18.0)	Amputation: musculoskeletal system and connective tissues disorders (6.0)
Other hepatobiliary or pancreas operating procedures	25.7	Peripheral vascular disorders (11.5)	G.I. obstruction (7.7)
Amputation for circulatory system disorders except upper limb & toe	22.4	Amputation: musculoskeletal system & connective tissues disorders (8.8)	Amputation: circulartory system disorders (8.1)
Other circulatory system operating procedures	21.3	Other circulatory system diagnoses (12.1)	Heart failure (11.4)
Other endocrine, nutritional and metabolic disease operating procedures	20.6	Heart failure (7.1)	Other circulatory system diagnoses (5.5)
Other digestive system operating procedures	19.7	G.I. hemorrhage (6.6)	Heart failure (6.6)
Skin grafts and wound debrid for endocrine, nutritional and metabolic disorders	18.6	Other circulatory system diagnoses (7.4)	Septicemia (7.4)
Hepatobiliary diagnostic procedure for non-malignancy	17.8	Esophagitis, gastroent and miscellaneous disorders (15.4)	Dirrhosis & alcoholic hepatitis (15.4)
Amputation for musculoskeletal system and connective tissues disorders	17.0	Amputation: circulartory system disorders (8.1)	Renal failure (6.5)
Pancreas, liver & shunt procedures	16.9	Postoperative infections (15.8)	Other digestive system diagnoses (7.9)

Table 4.18 Readmission Rates in Study Hospitals, Hospital Level (N=528)

Interval after Discharge	Cumulative Readmissions by the End of Period			
	Mean	**SD**	**Median**	**Range**
0-7 days	0.04	0.19	0.04	0-0.20
8 - 15 days	0.07	0.03	0.06	0-0.25
16 - 21days	0.08	0.03	0.08	0-0.26
22 - 30 days	0.10	0.03	0.10	0-0.28
31 - 60 days	0.15	0.05	0.14	0.01-0.40
61 - 90 days	0.18	0.05	0.17	0.03-0.43

Figure 4.6 Distribution of Hospital 30-day Readmission Rates, Hospital Level



Thirty-day Readmissions and Patient Characteristics

The distribution of 30-day readmissions by patient characteristics is described in Table 4.19. Overall, older, male, black patients were more likely to have a readmission within 30 days from discharge. Along with the increase in the number of comorbidities as well as the number of readmissions in 180 days prior to the index admission, 30-day readmission rates increased significantly.

Figure 4.7 illustrates cumulative hazard estimates for readmissions within 30 days from discharge by gender. Male patients had a higher hazard for readmissions at each time point over the 30-day observation period than female patients. The difference of hazard for readmissions was significant ($p<0.001$).

Figure 4.8 illustrates cumulative hazard estimates for readmissions within 30 days from discharge by race. Black patients had the highest hazard for readmissions over the 30-day observation period. Results from the log-rank tests show that the hazard for readmissions for black patients was significantly different from the hazard for white patients ($p<0.001$) and the hazard for other patients ($p<0.001$); the difference between white patients and other patients was not significant ($p=0.117$).

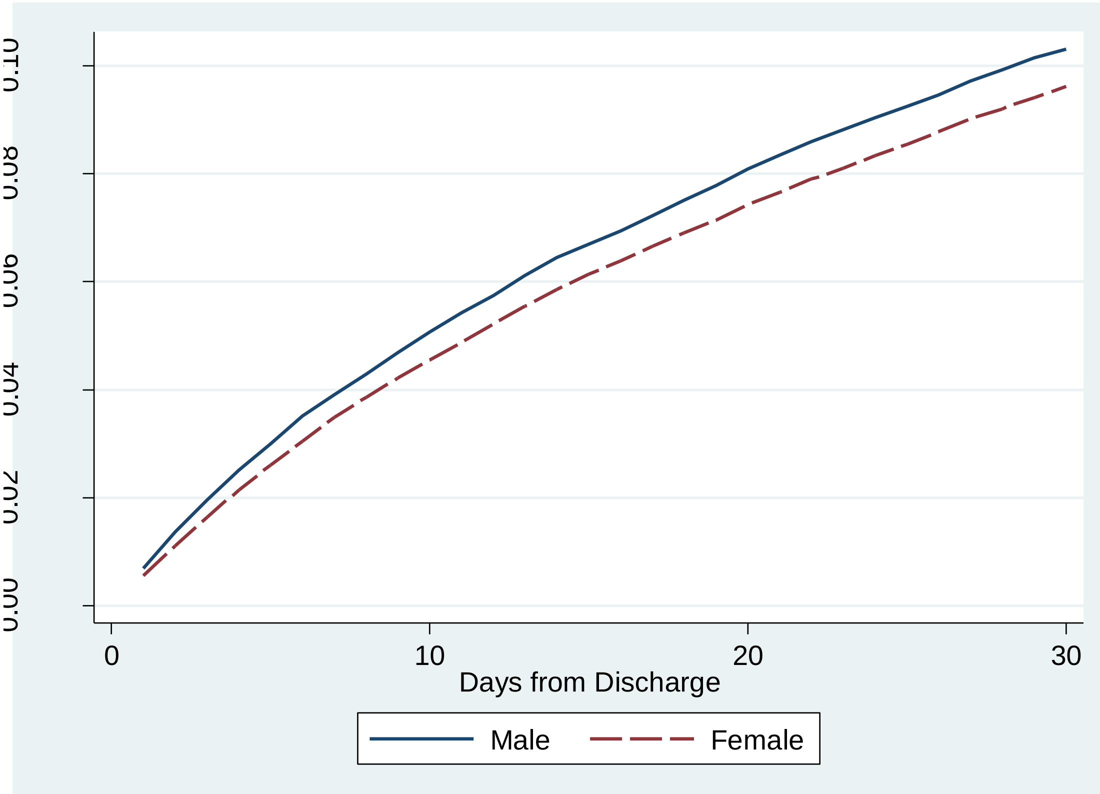
Table 4.19 Thirty-day Readmissions by Patient Characteristics (N=220,914)

	Not readmitted		**Readmitted**	
	N	**%**	**N**	**%**
Age (Mean, SD) ***	76.1	6.3	76.9	6.7
Gender * **				
Male	84,167	90.2	9,160	9.8
Female	115,860	90.8	11,727	9.2
Race***				
White	180,112	90.8	18,354	9.3
Black	8,251	86.5	1,285	13.5
Others	11,664	90.3	1,248	9.7
No. of comorbidities † * **				
0	22,943	94.3	1,393	5.7
1	55,761	93.0	4,191	7.0
2-4	110,117	89.7	12,606	10.3
5 or more	11,206	80.6	2,697	19.4
No. of admissions within prior 180 days * **				
0	161,019	91.9	14,117	8.1
1	27,953	87.2	4,098	12.8
2 or more	11,055	80.5	2,672	19.5

*** p<0.001;

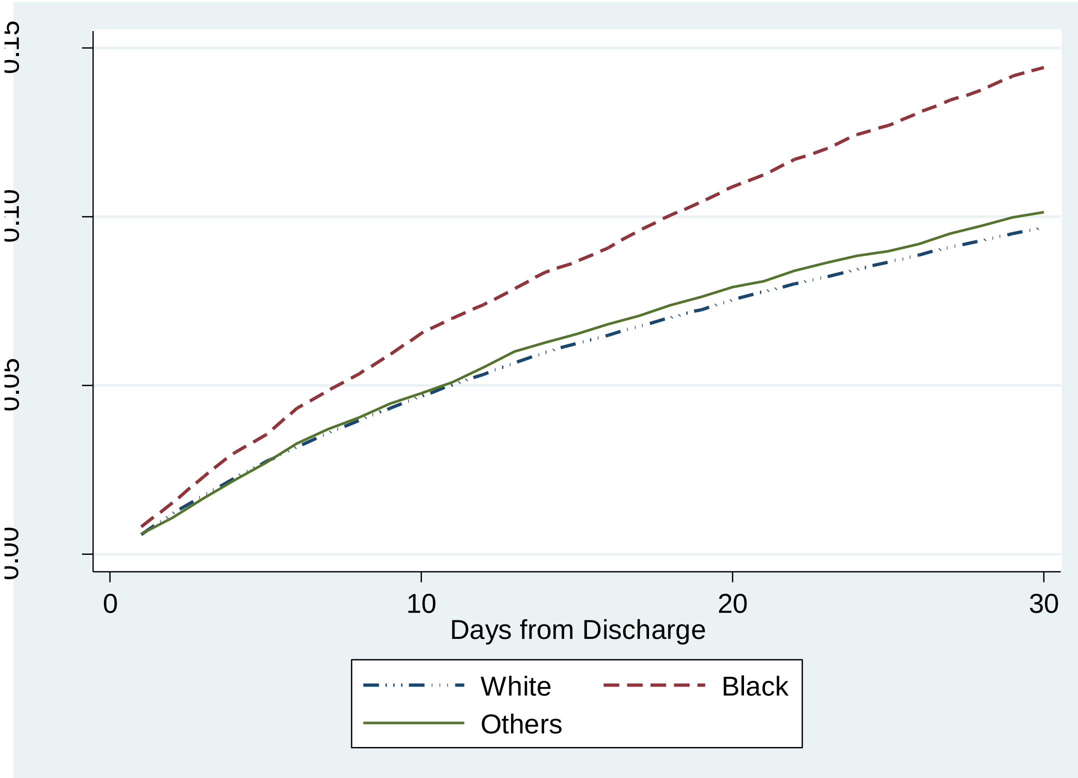
† based on diagnostic information of secondary diagnoses of index admissions and primary and secondary diagnoses of admissions within prior180 days of index admission

Figure 4.7 Nelson-Aalen Cumulative Hazard Estimates for Readmissions by Gender



Log-rank test for equality of survivor functions between male and female patients: p<0.001

Figure 4.8 Nelson-Aalen Cumulative Hazard Estimates for Readmissions by Race



1. Overall Log-rank test for equality of survivor functions: p<0.001;
2. Log-rank test for equality of survivor functions between black patients and white patients: p<0.001;
3. Log-rank test for equality of survivor functions between black patients and other patients: p<0.001;
4. Log-rank test for equality of survivor functions between white patients and other patients: p<0.117;

30-day Readmissions and Hospital Characteristics

Table 4.20 presents the 30-day readmission rates by hospital characteristics. Patients discharged from larger, teaching, and urban hospitals were more likely to be readmitted within 30 days from discharge. The 30-day readmission rates did not vary significantly by hospital ownership (not-for-profit vs. for profit) or hospital technology level (with or without the capacity of providing services of open-heart surgery and/or organ transplantation). The association between 30-day readmissions and hospital ownership as well as the association between 30-day readmissions and hospital high technological status were further examined utilizing bivariate logistic regression models when considering clustering at hospital level (not presented in Table 4.20). The results indicated that neither of these two hospital characteristics were significantly associated with 30-day readmissions (ownership: OR: 0.99, C.I. 0.92-1.06, p-value: 0.834; high technology: OR: 0.96, C.I. 0.92-1.03, p-value: 0.366); thus they were omitted from the final models as controlling variables.

30-day Readmissions and Hospital Nursing Organization

The distribution of 30-day readmissions by features of the hospital nursing organization is described in Table 4.21. All three nursing variables were significantly associated with 30-day readmissions as tested utilizing Chi-square tests. Hospitals with better nurse work environment (as measured with a higher score of the PES-NWI) and better nurse staffing (measured as fewer patients per nurse) had lower 30-day readmission rates, while interestingly hospitals with more nurses prepared at the baccalaureate educational level had higher readmission rates.

Table 4.20 Thirty-day Readmissions by Hospital Characteristics (N=220,914)

	Not readmitted		Readmitted	
	N	**%**	**N**	**%**
Ownership				
Not for profit	167,203	90.5	17,481	9.5
For profit	32,824	90.6	3,406	9.4
Bed size* **				
Small (<=100)	7,259	92.0	633	8.0
Medium (101-250)	56,844	90.3	6,077	9.7
Large (>=251)	135,924	90.5	14,177	9.5
Teaching status* **				
Non-teaching	96,066	91.0	9,498	9.0
Minor	83,965	90.3	9,063	9.7
Major	19,996	89.6	2,326	10.4
Technology level				
Not high tech	61,387	90.4	6,533	9.6
High tech	138,640	90.6	14,354	9.4
Location*				
Rural	10,050	91.1	976	8.9
Urban	189,977	90.5	19,911	9.5

* p<0.05; *** p<0.001

Table 4.21 Thirty-day Readmissions by Hospital Nursing Organization (N=220,914)

	Not readmitted		**Readmitted**	
	N	**%**	**N**	**%**
PES-NWI* **				
1 SD below mean	19,867	89.9	2,244	10.2
Within 1 SD below mean	58,130	90.3	6,281	9.8
Within 1 SD above mean	80,181	90.5	8,425	9.5
1 SD above mean	41,849	91.4	3,937	8.6
Nurse staffing* **				
<=4 patients per nurse	37,704	90.9	3,792	9.1
5 patients per nurse	76,725	90.6	7,985	9.4
6 patients per nurse	55,366	90.7	5,696	9.3
>=7 patients per nurse	30,232	89.9	3,414	10.2
Nurse education**				
<=20% with BSN or above	13,530	90.8	1,365	9.2
>20% & <=30%	34,529	90.9	3,458	9.1
>30% & <=40%	60,181	90.7	6,193	9.3
>40%	91,787	90.3	9,871	9.7

*****p<0.05, ******p<0.01; *******p<0.001; Percentages may not be equal to 100% due to rounding.

Specific Aim 2

Specific Aim 2: To identify the extent to which hospital nursing organization - nurse work environment, nurse staffing, and nurse education - were associated with 30-day readmissions in Medicare patients undergoing general, orthopedic, and vascular surgeries.

The association between hospital nursing organization and 30-day readmission was examined utilizing logistic regressions when accounting for clustering within each hospital. Three levels of analysis were conducted. First, bivariate association between 30-day readmissions and each feature of hospital nursing organization were examined. Then, patient characteristics (including patient demographics, comorbidities, prior utilization of healthcare, and types of surgery) and hospital structural characteristics (bed size, teaching status, and location) were added into each of the three models for risk-adjustment. Finally, the joint effect of nurse work environment and nurse staffing on 30-day readmission was examined.

The results from the aforementioned analysis are presented in Table 4.22. In the unadjusted bivariate models, both nurse work environment and nurse staffing were significantly associated with 30-day readmissions in the hypothesized direction; nursing education was associated positively with 30-day readmissions in the opposite direction as hypothesized. Furthermore, nurse work environment and nurse staffing continued to be significantly associated with 30-day readmissions when controlling for patient characteristics and hospital characteristics. The joint effect of different features of hospital nursing organization on 30-day readmission was further examined by including nurse staffing and work environment into one model. These results demonstrate that the nurse work environment still had a significant impact on 30-day readmissions when controlling for nurse staffing levels.

Analyses were conducted to further investigate how each attribute of the nurse work environment was associated with 30-day readmissions among the study patients. Four attributes of the nurse work environment (measured using the PES-NWI) were used in this study, including nurse participation in hospital affairs; nursing foundation for quality of care; nurse manager ability, and support of nurses; and collegial nurse-physician relations. Due to the high correlation among these subscales, the effect of each of these attributes of the nurse work environment on readmission was examined separately. The results are presented in Table 4.23. All four studied attributes of the nurse work environment were significantly associated with 30-day readmissions in the bivariate analysis. Three of the four attributes continued to be significantly associated with 30-day readmissions after adjusting for patient characteristics (including patient demographics, comorbidities, prior utilization of healthcare, and types of surgery) and hospital structural characteristics (bed size, teaching status, and location).

Table 4.22 The Effects of Hospital Nursing Organization on 30-day Readmissions (N=220,914)

	Unadjusted, separate			**Adjusted, separate**			**Adjusted, joint**		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Work environment	0.95	0.92-0.97	0.000	0.97	0.95-0.99	0.003	0.97	0.95-1.00	0.030
Nurse staffing	1.03	1.00-1.05	0.027	1.03	1.00-1.05	0.015	1.01	0.99-1.04	0.225
Nurse education†	1.22	1.01-1.48	0.039	1.06	0.90-1.24	0.504	-	-	-

Patient information (demographics, comorbidities, prior utilization of healthcare, and types of surgery) and hospital structural characteristics (bed size, teaching status, and location) were used as control variables in adjusted models. Clustering within each hospital was also adjusted.

†Nurse education was not included in the joint model

Table 4.23 The Effects of Work Environment (at Subscale Level) on 30-day Readmissions

	Unadjusted			**Adjusted**		
	OR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Nurse participation in hospital affairs	0.96	0.94-0.99	0.007	0.98	0.96-1.00	0.062
Foundations for quality of care	0.95	0.93-0.98	0.000	0.97	0.95-0.99	0.010
Nurse manager ability, leadership, and support of nurses	0.93	0.91-0.96	0.000	0.96	0.94-0.99	0.003
Collegial nurse-physician relations	0.95	0.93-0.98	0.000	0.97	0.95-0.99	0.002

1. The effect of each attribute of the nurse work environment were examined in separate models due to the high correlation between them
2. Standardized logistic regressions were used in this analysis. Standardized logistic regressions allowed the researcher to interpret the results as the expected change in the outcome corresponding with a 1 standard deviation (SD) change in the predictors of interest.

Additional Analyses

Additional analyses were conducted to investigate 30-day readmissions in relation to hospital length of stay (measured as days from the day of admission to the day of discharge), discharge destination (measured as home and not-to-home), readmission sources (measured as readmitted through emergency room, physician referrals, and other), and readmission hospitals (the same hospital as for index admission or a different hospital).

Table 4.24 presents patients' length of hospital stay of index admission and 30-day readmissions. Patients who were readmitted within 30 days from discharge had a significantly longer stay during their index admissions than patients without 30-day readmissions. Specifically, patients who were readmitted within 30 days stayed approximately 2 more days on average than those not readmitted within 30 days (median: 3 days vs. 5 days; SD: 4.6 days vs. 6.7 days). The distribution of hospital length of stay during index admission by 30-day readmission is also illustrated in Figure 4.9. In this figure, only hospital stays that were not claimed as outlier stays in the Medicare Provider Analysis and Review (MedPAR) records were included. Further examination of the association between length of hospital stay of index admission and 30-day readmission using risk-adjusted robust logistic regression controlling patient and hospital characteristics revealed a statistically significant relationship (OR: 1.05, 95% CI: 1.05 – 1.06, $p<0.001$).

The association of patients' discharge destination from index admissions and 30-day readmissions is presented in Table 4.25. Approximately 69% of the patients were discharged home from the index admission, while 31% were discharged to health services organizations, including skilled nursing facilities, long-term care hospitals, and other health services organizations. Among the patients discharged to home, 70% of them (or 48% of the 220,914 study patients) were discharged home for self-care; and 30% (or 21% of the 220,914 study patients) were discharged home requiring home care services. Patients who were discharged home for self-care were least likely to be readmitted within 30 days, compared to patients discharged home requiring home care services and discharged to health service organizations (8% vs. 9% vs.12%).

Among the 20,887 30-day readmissions in the study patients, two thirds were readmitted through the emergency room. Approximately 80% of the readmitted patients were rehospitalized into the same hospitals in which patients were initially admitted.

Table 4.24 Patient Hospital Length of Stay during Index Admissions and 30-day Readmissions (N=220,914)

	Length of stay (days)			
	Mean	**Median**	**SD**	**Range**
30-day readmission ***				
No (N=200,027)	4.6	3	4.6	1-232
Yes (N=20,887)	6.8	5	6.7	1-103
Total	4.8	4	4.9	1-232

*** p<0.001

Figure 4.9 Patient Hospital Length of Stay by 30-day Readmissions

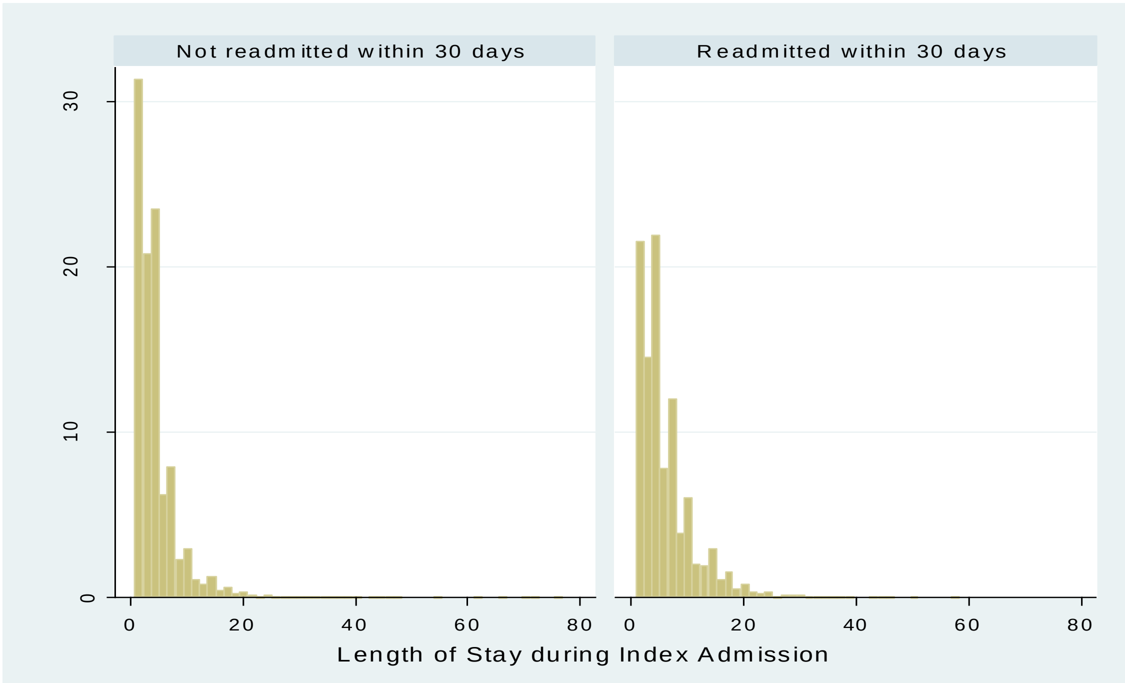


Table 4.25. Discharge Destination from Index Admission and 30-day Readmissions (220,914)

	Proportion of discharges		30-day readmissions	
	N	**%**	**N**	**%**
Discharge destination				
Home/self-care	106,281	48.1	8,718	8.2
Home/ home care service	45,929	20.8	4,082	8.9
Health care facilities	68,704	31.1	8,087	11.8

Home/home care service indicates that patients required home care services after discharge home
Health care facilities include skilled nursing facility, long-term care hospitals, rehabilitation facility, and other health care services facilities/organizations

CHAPTER 5: DISCUSSION

Introduction

Given its preventability, prevalence, high cost, and potential harm to patients, identifying effective interventions to reduce readmissions has become crucial. Hospital nursing is a critical element of the hospital health service system and fully manageable by hospital administrators. This study was designed to investigate the role of hospital nursing in readmissions in surgical Medicare patients, a group of potentially vulnerable patients that have not been well studied. A cross-sectional design utilizing secondary data from patients, nurses, and hospitals was used to address the specific aims. In this chapter, the principal findings from analysis are summarized and discussed. It is followed by a discussion of the limitations of the study and the implications of the results from this study for policy makers, hospital administrators, and health care providers. Finally, recommendations for future studies are discussed.

Discussion of Principal Findings

The findings from this study suggest that readmissions among surgical patients are not uncommon and are worth more attention from health professionals and policy makers. This study also suggests that improving the hospital nurse work environment and nursing staffing can be effective strategies to prevent readmissions in Medicare patients. As hypothesized, I found that both the hospital nurse work environment and nurse staffing were significantly associated with hospital readmissions in surgical Medicare patients. This study, to the best of my knowledge, is the first study examining the relationship between organization of hospital nursing and surgical readmissions. Findings from this study bring new insights into the extant body of knowledge regarding the nursing-outcomes relationship.

The incidence, variation, and reasons of 30-day readmissions in Medicare patients undergoing general, orthopedic, and vascular surgeries

The findings from this study show that early readmissions after surgery procedures are very common in Medicare patients. The overall 30-day readmission rate was 10% (20,887 patients) in the 220,914 study patients, which may be higher than expected. This study also reported 30-day readmission rates for each surgical category (11% for general surgeries, 8% for orthopedic surgeries, and 12% for vascular surgeries). These findings are similar to the reported surgical readmission rates by other researchers. In a study of 10,882 patients undergoing colorectal surgery, Wick et al observed a 30-day readmission rate of 11% (Wick et al., 2011). In another study of Medicare patients, Press et al reported 30-day readmission rates of 12% in patient of general surgeries, 9% in patients of orthopedic surgeries, and 19% in patients of vascular surgeries (Press et al., 2010). The differences between this study and the study by Press et al may reflect geographic difference of the study sample and methodological differences rather than a temporal trend. In this study, only patients admitted into acute care hospitals in California, Florida, New Jersey, and Pennsylvania were included; while in Press's study, the study sample was comprised of all Medicare patients admitted into acute care hospitals in 2005. Also in this study patients who were transferred from other hospitals were excluded. These patients may be sicker and thus more likely to be readmitted after discharge.

Similar to previous studies, this analysis shows that the risk of readmission after discharge persists over time (Table 4.12); and this risk decreases as the time from discharge extends (Figure 4.5). For example, the 30-day readmission rate was 2.6 times of the 7-day readmission rate; and the 60-day readmission rate was1.5 times of the 30-day readmission rate. This finding suggests that preventing early readmissions should be considered as a priority when health resources are limited.

Majority Medicare patients have at least one chronic condition. Undergoing surgery may increase the risk of readmission for Medicare patients. Because these patients require more complicated care compared to patients without chronic conditions. In this study, I found that 89% of the study patients had at least one comorbid condition and 61% had two or more. I also found that patients were more likely to be readmitted for medical conditions; although they were initially hospitalized for surgeries. Nine out of the10 identified Diagnosis Related Groups (DRGs) that accounted for the most frequent reasons for 30-day readmissions are medical conditions (Table 4.14). These 10 DRGs included cardiovascular conditions (heart failure and shock and cardiac arrhythmia), conditions related to the digestive system (esophagitis, gastroenteritis, and miscellaneous disorders, gastrointestinal bleeding, and other digestive disorders), infections (postoperative infections, operating procedure for infections, and pneumonia and pleurisy), renal failure, and other complications of treatment. They accounted for one third of the 20,887 readmissions within 30 days from discharge identified in this study. This finding is consistent with findings from other studies (Jencks, et al., 2009).

Another informative finding is that infection was a very frequent reason for 30-day readmissions. For example, postoperative infection is the 3rd most frequent reason for readmission in this study (Table 4.14); it also occurred frequently in patients in the most common DRGs for index admission or DRGs with highest 30-day readmission rates. Other frequent occurred infection-related DRGs for readmissions include operating procedure for infections, pneumonia, septicemia, and kidney and urinary infections. The occurrence of post-discharge infection may result from substandard inpatient care during the index hospitalization, such as failure to early detect sign of infection or inappropriate medication prescription. It may be also attributable to lack of self-care knowledge in patients, which can be traced back to inadequate discharge preparation and patient education.

Significant associations between patient characteristics (age, gender, race/ethnicity, comorbidities, and prior health utilization) and 30-day readmission were observed in this study. Researchers have consistently found that black patients are at higher risk for readmissions than non-black patients (Joynt, et al., 2011; Kansagaran, et al., 2011). This relationship was observed in this study too. Black patients had the highest readmission rates (14%), compared to either white patients (9%) or patients of other races/ethnicities (10%). Black patients were also more likely to have surgeries at a younger age (Figure 4.3). It also should be noted that only 4.3% of the study patients were black. Another study of Medicare patients undergoing total hip arthroplasty also reported that only 4.6% of these patients were black (Cram, et al, 2011). While according to the U.S. Department of Health and Human Services, 8.3% of the older adults (65 year or above) are black (AOA, 2010a). These findings suggest that a racial disparity may exist in access to health care services.

Utilizing diagnostic information from the index admission as well as admissions in 180 days prior to index admission, I found that approximately 62% of the patients had multiple comorbidities (2 or more), which echoes findings from previous study (Timms, et al., 2002). Moreover, as the number of comorbidities increased, the risk for readmission also increased significantly. For example, patients with 5 or more comorbidities had a 30-day readmission rate of 19%, and patients without comorbidity had a 30-day readmission rate of 6%. Also notable is the significant association between early health utilization and readmissions, which have been suggested in many studies but rarely investigated due to availability of patient clinical information. In this study, patients had two admissions or more in 180 days prior to index admission had a 30-day readmission rate of 20%, while patient without any admission in prior 180 days had a readmission rate of 8%. This suggests that information of patients' prior utilization of healthcare should also been considered when identifying high risk population for readmissions in the future.

Hospital characteristics have been frequent used as risk factors in models predicting hospital readmissions. Five hospital characteristics, including ownership (not-for-profit or for-profit), bed size (small, medium, and large), teaching status (nonteaching, minor, and major), technology level (high technology or not, and location (urban or rural), were examined in relation to 30-day readmissions. Different from Joynt et al.'s study of readmission among heart failure patients as well as some other studies is that this study did not find significant associations between hospital ownership and readmissions or between hospital technology level and readmissions. This may be because only private hospitals were included in this study. Public or federal hospitals, which were excluded, usually have difficult in keeping sufficient and consistent funding. This has been independently linked public or federal hospitals to poor-quality care (K. E. Joynt & Jha, 2011). High technology hospitals were defined as hospitals providing services of open-heart surgery, organ transplantation, or both; while the patients included herein were patients undergoing general surgeries (28%), orthopedic surgeries (49%), and vascular surgeries (23%). No transplant patients and open-heart surgery patients were included in this study.

Significant associations were found between 30-day readmissions and hospital bed size, teaching status, and location; however these associations were in opposite directions as reported by other researchers (Joynt & Jha, 2011; Khuri, et al., 2001). Other researchers have reported that patients discharged from larger, major teaching, and urban hospitals had lower readmission rates; while I found that patients cared in small, non-teaching, and rural hospitals had lower readmission rates among surgical patients. This may be explained by the fact that patients admitted to larger, major teaching, and urban hospitals had with higher severity levels or for more complex surgeries. This was supported by the multivariate analysis that when adjusting for patient characteristics, the association between hospital characteristics and readmission became not significant (bed size and location) or less significant.

The association between hospital nursing organization (work environment, nurse staffing, and nurse education) and 30-day readmission among Medicare patients undergoing general, orthopedic, and vascular surgeries

A thorough exploration of the association hospital nursing organization and readmissions was conducted. Analysis was first conducted to examine the binary association between 30-day readmission and each feature of hospital nursing organization, specifically, nurse work environment, nurse staffing, and nurse education; then the effects of nurse work environment, nurse staffing, and nurse education on 30-day readmissions were examined independently using multivariate logistic regression models when controlling for patient characteristics and hospital characteristics as well as the clustering at hospital level; finally, the effects of nurse work environment and nurse staffing on 30-day readmissions were examined jointly in a fully adjusted model. Significant associations between nurse work environment and readmission and between nurse staffing and readmission were observed among surgical Medicare patients.

Nurse work environment and 30-day readmissions

This study provides the first evidence that better nurse work environment has a protective effect on the risk for readmissions among older patients undergoing surgeries. In the multivariate model adjusting for both patient characteristics and hospital characteristics, I found that one unit increase in PES-NWI score (measured continuously and in standard deviation units) led to 3% decrease in the likelihood of 30-day readmissions (OR: 0.97, 95% CI: 0.95-0.99, p-value: 0.003). In other words, if moving hospitals at 16th percentile in term of their PES-NWI score to 50th percentile, the risk for

30-day readmission in patients discharged from these hospitals would decrease by 3%. Although this effect is not very large; it is still very meaningful given the difficulties in reducing readmissions. It should be noted that even when adding nurse staffing into the model, the association between nurse work environment and 30-day readmission was still significant and in the hypothesized direction (OR: 0.98, 95% CI: 0.95-1.00, p-value: 0.045). The findings here provide evidence that favorable nurse work environments may be important in preventing readmissions among surgical patients.

Nurse work environments include a variety of features. Herein, additional analysis was conducted to explore each measured attribute of the nurse work environment in association with readmissions (Table 4.22). The results show that three of the four study attributes of the nurse work environment were significantly associated with 30-day readmissions among surgical Medicare patients after risk-adjustment; the other one also had a marginal significance. These findings suggest that all these attributes should be considered by policy makers and hospital administrators when improving the hospital work environment.

Nurse staffing and 30-day readmission

Hospital nurses are one of the most important health care providers for patients. Nurse staffing levels reflect different care workload to nurses. Theoretically and empirically, nurse staffing, despite the difference in measuring tools, is an important factor influencing quality of inpatient care and patient outcomes. However, only two studies thus far have investigated the relationship between nurse staffing and readmission (Diya, et al, 2011; Joynt & Jha, 2011). One of them studied readmission among heart failure patients and found that hospitals with the nurse-to-census ratio in the lowest quartile had the highest 30-day readmission rates.

This significant association between hospital nurse staffing and patient readmissions was also observed in this study, which contributes to the body of existing evidence that hospital nurse staffing levels are one of the most consistent and prominent organizational factors impacting patient outcomes. When controlling for patient and hospital characteristics, my analysis showed that adding one additional patient per nurse, patients' odds of being readmitted within 30 days of discharge would increase by 3%. This significance was not observed when I further included nurse work environment into the model. This does not warrant concluding that nurse staffing has no impact on patients' risk for readmissions. This is more likely that the nurse work environment measures hospital nursing in a broader way and it may also indirectly reflect some degree of hospital nurse staffing level. In this study, the correlation coefficients between hospital nurse staffing (patient to nurse ratio) and the four subscales used to measuring quality of nurse work environment ranged from - 0.30 to - 0.38 (Table 4.11). This also suggests that nursing staffing is important in preventing readmissions; but nurse work environment is more important.

Nurse education and 30-day readmission

Despite previous reports of the significant association between hospital nurse education compositions (measured as proportion of nurses with bachelor's degrees and above) and patient outcomes; this study did not find a significant effect of nurse education on readmission. This may be partially explained by the association between the level of hospital nurse education and hospital characteristics. Both in this study and from previous research, it has reported that hospitals with higher proportion of nurses with bachelor's degrees or above tended to be larger and have higher medical trainee-to-bed ratios (Aiken, et al., 2003). As discussed above, patients in larger major teaching hospitals were sicker and more likely to undergo complex surgeries; thus it may trade-off the effect of nursing education on readmissions. In addition, newly graduated nurses are more likely to have a baccalaureate degree; and on the other hand, they are less experienced. This may attenuate the association between nurse education and readmissions (Blegen, Vaughn, & Goode, 2001). A systematic review of studies examining the association between nursing education and patient outcomes concluded that further research to investigate the role of nursing education in patient outcomes is needed given that the extant evidence is not conclusive (Ridley, 2008).

Findings from additional analysis

Some interesting findings have been observed from additional analysis. Reduction in length of stay has been considered as a way of increasing hospital productivity, because it increases patient turnover and result in more available beds. On the other hand, it has been speculated that lowering the length of hospital stay may result in worse outcomes, including increased hospital readmissions. Inconsistent findings regarding the association between hospital length of stay during index admission and readmission rates has been reported (Heggestad, 2002; Mnatzaganian, Ryan, Norman, Davidson, & Hiller, 2012). In a study by Heggestad et al, shorter length of stay during index admissions significantly increased patients' risk for 30-day readmissions among a national Medicare sample; while Mnatzaganian et al reported that no significant association between hospital length of stay and readmissions were observed. It is noeworth that in both studies aforementioned, patient characteristics and hospital characteristics were used as control variable; however, feature of hospital nursing organization were not included.

In my study, a significant relationship between longer length of stay and higher risk for readmissions were observed. Patients who were readmitted within 30-days of discharge had a significantly longer hospital stay than those without a 30-day readmission in the binary analysis (mean: 7 days vs. 5days; median: 7days vs. 5 days; SD: 5 days vs. 3 days). Further analysis of adjusting for patient characteristics and hospital characteristics indicated that the difference continued to exist and be significant. One possible explanation of this phenomenon is that substandard care (e.g. failure to detect and prevent postoperative complications) from hospitals not only delays the recovery process after surgeries but also increase the risk for readmissions (Theisen, Drabik, & Stock, 2012). The association between length of stay and quality of hospital care (including nursing care) thus should be further investigated.

Different 30-day readmission rates were observed in patients discharged to different destinations. Patients who were discharged to health care facilities (e.g. skilled nursing facility, rehabilitation facility, and long-term care facility) had a higher 30-day readmission rate, compared to patients discharged home, either with or without home care services. Among patients discharged home, those who were assigned with home care services had a higher 30-day readmission rate that those without home care services. One possible explanation is that patients discharged to health care facilities are the sicker ones (such as patients have more comorbidities and postoperative complications), and patients discharge to home without home care services are the least sick ones. It is also possible that an over reliance on the degree of support from health care facilities and home care services occurred; and patients' involvement in care was discouraged. Nursing facilities may also expose those patients to nosocomial pathogens, which could increase septic complication rats and severity. Further research is need to identify why differences in risk for readmissions exists among patients with different discharge destinations.

Limitations of the Study

This study has some limitations; and most of them are due to the utilization of secondary data for analysis. A common limitation in secondary analysis is the reliance on data collected by other investigators for other research purposes. In this study, information used to measure the hospital nursing organization was collected previously in 2006-2007, for a different but related research purpose. Despite this restriction, the utilization of this large scale nurse survey provides the author a unique opportunity to examine the nursing-readmission relationship, which has been rarely studied. The strengths of using this nurse data include: 1) all the information on nursing organization was obtained directly from registered nurses who providing direct patient care (over 100,000 in the parent study, and over 20,000 in this study); 2) the data on nurse work environment was unique and not available elsewhere; 3) the measure of nurse staffing (patient-to-nurse ratio) was derived from nurses providing direct care and thus is better indicators of clinical care workloads than administrative data sources which also include nurses in outpatient settings and on administrative positions (Aiken, et al., 2011).

The use of administrative data to obtain patient discharge information may also present some limitations. All the patient comorbid information for risk adjustment in this study was derived from patient discharge data. It is common for administrative data that diagnosis and procedure that are directly related to the primary diagnosis are more likely to be coded. In addition, common comorbid conditions (e.g. hypertension and delirium) are coded more often in healthier patients who have few other comorbid conditions than in sicker patients who had more competing comorbidities to include for billing. This is often described as the “crowding out” phenomenon. These inherent limits hampered this study’s ability to account for variations in severity of illness among the study population. Recognizing the inherent limitation of administrative data, I used a 180-day look back period to better capture patients’ comorbid information. All information from secondary diagnoses of index admission, as well as from primary and secondary diagnoses of any admissions within 180 days prior to index admission was used to identifying patients’ comorbidities.

The association between hospital nurse work environment, nurse staffing, and readmissions may be underestimated. First, this study was limited to examine only one surgical admission per patients during a period of 12 months, as well as only the first readmission within 30 days from discharge was counted. Patients who are hospitalized more frequently are more likely to be readmitted again, which implies the readmission rates among surgical patients may be higher than my estimation. Yet my method of choosing one single admission for each patient ensures the independence of statistical tests. Second, the outcome herein was defined as “all-cause” readmissions. Some of the readmissions may not be related to quality of care (including nursing care) and thus unavoidable. However, this is the first study examining the association between features of hospital nursing organization and readmission among surgical Medicare patients; any findings from this study will advance our knowledge of the nursing-readmission relationship. In addition, there is thus far no reliable way to determine whether a readmission is preventable or not using administrative data of large sample size (Horwitz, et al., 2011).

Another limitation of this study results from the nature of cross-sectional design – insufficient to identify causality. Caution should be applied when interpreting the results from this study. The identified association between hospital nursing organization (both nurse work environment and nurse staffing) and readmissions in this study is correlational, not causal. To identify a causal relation, longitudinal data will be required. It would be ideal if the data could link nurses to patients whom they cared for. However, giving the lack of evidence linking organization of hospital nursing to readmission, a cross-sectional study design is appropriate to determine whether this relation exists or not.

Implications

The findings from this study have several important implications. First, findings from my study suggest that readmissions following surgical hospitalization are common; and even higher than expected for certain surgical procedures. In this study, a 10% readmission rate was observed among surgical Medicare patients; and the readmission rate in patients undergoing some surgical procedures can be as high as 26%. However, research on readmissions thus far has primarily focused on patients with chronic medical conditions. My study suggests surgical readmissions deserve more attention from policy makers and hospital administrators. This study also point out that among the patients undergoing general, orthopedic, and vascular surgeries, two subgroups should be highlighted: 1) patients in diagnosis-related groups accounted for largest number of index admissions (Table 4.14), such as patients hospitalized for major joint replacement, percutaneous cardiovascular procedures, and major bowel procedures; and 2) patients with highest readmission rates (Table 4.16), such as patients hospitalized for amputation for circulatory system disorders, hepatobiliary or pancreas operating procedures, and other circulatory system operating procedures. Particularly, the findings that patients for vascular surgeries had highest readmission rates among the three surgical groups (general, orthopedic, and vascular) confirmed the findings from previous studies; it also provides more research-based evidence to the intention of expanding of the “penalty incentive” strategy aiming to reduce readmissions under the Patient Protection and Affordable Care Act to vascular surgeries.

The results reported herein are informative to policy makers and hospital administrators in their effort to reduce readmissions. This study documented sizable and significant associations between favorable work environment and fewer readmissions. It also reported that nurse work environment is the most important factor related to readmissions among the three study hospital nursing factors. A favorable nurse work environment can be defined as a work setting facilitating professional nursing practice (Lake, 2002). Magnet hospitals are best exemplars of favorable work environment; and the blueprint for American Nurses Credentialing Center Magnet designation provides a guideline to hospital administrators for improving hospital work environment. In this study, it is also demonstrated that some attributes of work environment (nurses' participation in hospital affairs, foundations for quality of care, manager supervisory ability, and collegial relationships between nurses and other health professionals) are associated with readmissions. These findings provide more specific directions to hospital executives regarding how to initiate the work environment improvement programs. Hospitals' investment in these attributes of work environment will lead to better patient outcomes. Furthermore, other researchers have shown that reforming hospital nurse work environment can be accomplished at little cost (Mark, Lindley, & Jones, 2009).

Another potential intervention to prevent readmissions, as suggested by the findings from this study, is improving nurse staffing. It has been reported that nurses in hospitals with better nurse staffing levels are more capable of completing discharge education and having their prepared for discharge (Weiss, Yakusheva, & Bobay, 2011). Better nurse staffing also enables nurses to better perform early detection of adverse events and providing timely interventions, which in turn decreases patients' risk for undesirable outcomes, such as mortality and failure-to-rescue (Aiken, 2011). One concern for hospital executives regarding increasing nurse staffing levels is that it is associated with a direct cost. This may lead to the reluctance among hospital executives of hiring more nurses; however, researchers have documented that the cost of increasing nurse staffing can be set off, at least partially, by the ensuing improvement in quality of care and patient outcomes (Dall, Chen, Seifert, Maddox, & Hogan, 2009; Rothberg, Abraham, Lindenauer, & Rose, 2005). California is the first state and the only state thus far that has implemented a patient-to-nurse staffing ratio mandates. McHugh et al has reported that California's mandate has successfully improved nurse staffing in general; more important it also improved nurse staffing for hospitals serving more vulnerable patients (McHugh et al., 2012). Policymakers in other states may consider similar nurse staffing mandates as an effective way to improve hospital nurse staffing.

It should also be noted that improving the hospital work environment and nurse staffing contributes to more than just reductions in readmissions. Every patient is exposed to nursing care during his or her hospitalization. Numerous studies have linked more favorable work environment and better nurse staffing to other patient outcomes, including but not limited to mortality, failure-to-rescue, and complications. Thus, the overall benefits from improving work environment and nurse staffing will be potentially larger than other outcome-specific interventions (e.g. discharge preparation).

Recommendations for Future Research

Multiple opportunities exist for future investigation of the relationship between nursing and readmission. In this study, readmissions were defined as all-cause readmissions. It is important to know the pattern of readmissions for any reason; and it may be more important to hospital administrator and health care providers to identify readmissions that are related to inpatient care and preventable. More research is needed to identify preventable readmissions (including readmissions that are sensitive to nursing care). It is also notable that risks for readmission varied by patients conditions. An in-depth knowledge of causes of readmissions may be gained by further analysis of readmissions among patients for specific surgeries, particularly surgeries with higher readmission rates. This study has shown that infections are frequent reasons for readmissions following surgeries. However, due to the availability of patient information, this study is not able to identifying the association between inpatient care and infection-related readmissions.

This study focused on examining the role of hospital nursing organization, in which Medicare patients received inpatient care, in surgical readmissions. The organization of nursing in other health care setting was excluded from this study. Meanwhile, research has suggested that both inpatient care and post-discharge care (e.g. utilization of health care facilities and home care) are related to readmissions (Hansen, Young, Hinami, Leung, & Williams, 2011); and a large proportion of patients are discharged to health care facilities after surgery. Recent statistics have shown that the number of patients discharged to health care facilities is increasing (AOA, 2010a). It is thus desirable to examine the quality of hospital nursing organization in other organizational contexts; and investigate how it is related to readmissions as well as other patient outcomes. This type of research will further advance our knowledge of organization-outcome relationship. In this study, the role of hospital nursing organization in patient outcomes (herein readmissions) was examined through three different measures, nurse work environment, nurse staffing, and nurse education. Results from this study, particularly the analysis of the joint effect model, suggest that a composite measure of hospital nursing organization should be considered in future studies. The application of such a composite measure may provide new insight into the role of nursing in patient outcomes.

The prevalence of chronic conditions is very common among older patients. For example, I found 89% of the older adults had at least one comorbid condition and 62% had two or more. Older patients with chronic conditions are more vulnerable to undesirable outcomes. Undergoing surgery at an advanced age is another burden to older patients. Due to the research design, patients' comorbid conditions were only used as control variable for risk adjustment. Further research is needed to investigate the role of nursing care in patient outcomes when patients undergoing surgeries with the presents of chronic conditions, for example diabetes, congestive heart failure, and chronic obstructive pulmonary disease. Finally, this study only included fee-for-service Medicare patients undergoing general, orthopedic, and vascular surgeries. The role of nurse work environment and nurse staffing in readmissions has not been well studied in other patient populations. Future research that investigates this relationship in different types of patient populations would be desirable.

APPENDIX A

Diagnosis Related Groups (DRGs) for Surgical Patient Sample (Version FY2006)

General Surgery:

146-155, 157-162, 164-167, 170, 171, 191-201, 257-268, 285-293, 493, 494

Orthopedic Surgery:

210, 211, 213, 216-219, 223-230, 232-234, 471, 491, 496-503, 537, 538, 544

Vascular Surgery:

110, 111, 113, 114, 119, 120, 518, 555-558

APPENDIX B

Practice Environment Scale of the Nursing Work Index Subscale

1. Nurse Participation in Hospital Affairs
    - Career development/clinical ladder opportunity
    - Opportunity for staff nurses to participate in policy decisions
    - A chief nursing officer who is highly visible and accessible to staff
    - A chief nursing officer equal in power and authority to other top-level hospital executives
    - Opportunities for advancement
    - Administration that listens and responds to employee concerns
    - Staff nurses are involved in the internal governance of the hospital
    - Staff nurses have the opportunity to serve on hospital and nursing
    - Nursing administrators consult with staff on daily problems and procedures
2. Nursing Foundations for Quality of Care
    - Active staff development or continuing education programs for nurses
    - High standards of nursing care are expected by the administration
    - A clear philosophy of nursing that pervades the patient care environment
    - Working with nurses who are clinically competent
    - An active quality assurance program
    - A preceptor program for newly hired RNs
    - Nursing care is based on a nursing, rather than a medical, model
    - Written, up-to-date nursing care plans for all patients
    - Patient care assignments that foster continuity of care, i.e., the same nurse cares for the patient from one day to the next
    - Use of nursing diagnoses
3. Nurse Manager Ability, Leadership, and Support of Nurses
    - A supervisory staff that is supportive of the nurses
    - Supervisors use mistakes as learning opportunities, not criticism
    - A nurse manager who is a good manager and leader
    - Praise and recognition for a job well done
    - A nurse manager who backs up the nursing staff in decision making, even if the conflict is with a physician
4. Staffing and Resource Adequacy
    - Adequate support services allow me to spend time with my patients
    - Enough time and opportunity to discuss patient care problems with other nurses
    - Enough registered nurses to provide quality patient care
    - Enough staff to get the work done
5. Collegial Nurse-Physician Relations
    - Physicians and nurses have good working relationships
    - A lot of team work between nurses and physicians
    - Collaboration (joint practice) between nurses and physicians

APPENDIX C

Elixhauser's Comorbidity Measures for Use with Administrative Data (Elixhauser et al., 1998)

Comorbidity	ICD-9-CM Codes	DRG Screen: Case Does *Not* Have the Following Disorders
1. Congestive heart failure	398.91,402.11,402.91,404.11, 404.13, 404.91, 404.93, 428.0-428.9	Cardiac [a]
2. Cardiac arrhythmias	426.10, 426.11, 426.13, 426.2-426.53, 426.6-426.89, 427.0, 427.2, 427.31, 427.60, 427.9, 785.0, V45.0, V53.3	Cardiac [a]
3. Valvular disease	093.20-093.24, 394.0-397.1, 424.0-424.91, 746.3-746.6, V42.2, V43.3	Cardiac [a]
4. Pulmonary circulation disorders	416.0-416.9, 417.9	Cardiac [a] or COPD (88)
5. Peripheral vascular disorders	440.0-440.9, 441.2, 441.4, 441.7, 441.9, 443.1-443.9, 447.1, 557.1, 557.9, V43.4	Peripheral vascular (130-131)
6. Hypertension (combined)		
Hypertension, uncomplicated	401.1, 401.9	Hypertension (134)
Hypertension, complicated	402.10, 402.90, 404.10, 404.90, 405.11, 405.19, 405.91, 405.99	Hypertension (134) or cardiac [a] or renal [a]
7. Paralysis	342.0-342.12, 342.9-344.9	
8. Other neurological disorders	331.9, 332.0, 333.4, 333.5, 334.0-335.9, 340, 341.1-341.9, 345.00-345.11, 345.40-345.51, 345.80-345.91, 348.1, 348.3, 780.3, 784.3	Nervous system (1-35)
9. Chronic pulmonary disease	490-492.8, 493.00-493.91, 494, 495.0-505, 506.4	COPD (88) or asthma (96-98)
10. Diabetes, uncomplicated [b]	250.00-250.33	Diabetes (294-295)
11. Diabetes, complicated [b]	250.40-250.73, 250.90-250.93	Diabetes (294-295)
12. Hypothyroidism	243-244.2, 244.8, 244.9	Thyroid (290) or endocrine (300-301)
13. Renal failure	403.11, 403.91, 404.12, 404.92, 585, 586, V42.0,V45.1,V56.0,V56.8	Kidney transplant (302) or renal failure/dialysis (316-317)
14. Liver disease	070.32, 070.33, 070.54, 456.0, 456.1, 456.20, 456.21 571.0, 571.2, 571.3, 571.40-571.49, 571.5, 571.6, 571.8, 571.9,572.3,572.8, V42.7	Liver [a]

15. Peptic ulcer disease, excluding bleeding	531.70, 531.90, 532.70, 532.90, 533.70, 533.90,534.70,534.90, V12.71	GI hemorrhage or ulcer (174-178)
16. AIDS [b]	042-044.9	HIV (488-490)
17. Lymphoma	200.00-202.38, 202.50-203.01, 203.8-203.81, 238.6, 273.3,V10.71,V10.72,V10.79	Leukemia/lymphoma [a]
18. Metastatic cancer [b]	196.0-199.1	Cancer [a]
19. Solid tumor without metastasis [b]	140.0-172.9,174.0-175.9,179-195.8, V10.00-V10.9	Cancer [a]
20. Rheumatoid arthritis/collagen vascular disease	701.0, 710.0-710.9, 714.0-714.9, 720.0-720.9, 725	Connective tissue (240-241)
21. Coagulopathy	2860-2869, 287.1, 287.3-287.5	Coagulation (397)
22. Obesity	278.0	Obesity procedure (288) or nutrition/metabolic (296-298)
23. Weight loss	260-263.9	Nutrition/metabolic (296-298)
24. Fluid and electrolyte disorders	276.0-276.9	Nutrition/metabolic (296-298)
25. Blood loss anemia	2800	Anemia (395-396)
26. Deficiency anemia	280.1-281.9, 285.9	Anemia (395-396)
27. Alcohol abuse	291.1, 291.2, 291.5, 291.8, 291.9, 303.90-303.93,305.00-305.03, V113	Alcohol or drug (433-437)
28. Drug abuse	292.0, 292.82-292.89,292.9,304.00-304.93, 305.20-305.93	Alcohol or drug (433-437)
29. Psychoses	295.00-298.9, 299.10-299.11	Psychoses (430)
30. Depression	300.4, 301.12, 309.0, 309.1, 311	Depression (426)

ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification; DRG, diagnosis-related group; COPD, chronic obstructive pulmonary disease; GI, gastrointestinal; AIDS, acquired immune deficiency syndrome; HIV, human immunodeficiency virus.

[a] Definitions of DRG groups: Cardiac: DRGs 103-108, 110-112, 115-118, 120-127, 129, 132-133, 135-143; Renal: DRGs 302-305, 315-333; Liver: DRGs 199-202, 205-208,; Leukemia/lymphoma: DRGs 400-414, 473, 492; Cancer: DRGs 10, 11, 64, 82, 172, 173, 199, 203, 239, 257-260, 274, 275, 303, 318, 319, 338, 344, 346, 347, 354, 355, 357, 363, 366, 367, 406-414

[b] A hierarchy was established between the following pairs of comorbidities: if both uncomplicated diabetes and complicated diabetes are present, count only complicated diabetes. If both solid tumor without metastasis and metastatic cancer are present, count only metastatic cancer.

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